

The AMSAT[®] Journal

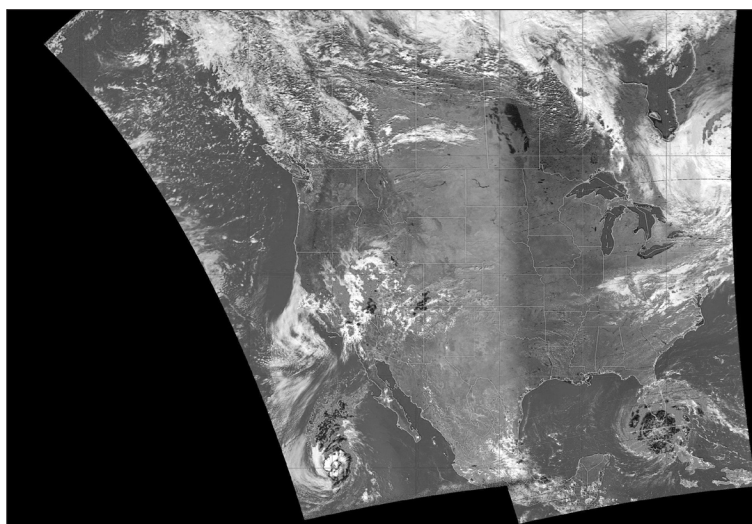


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Volume 30, Number 1

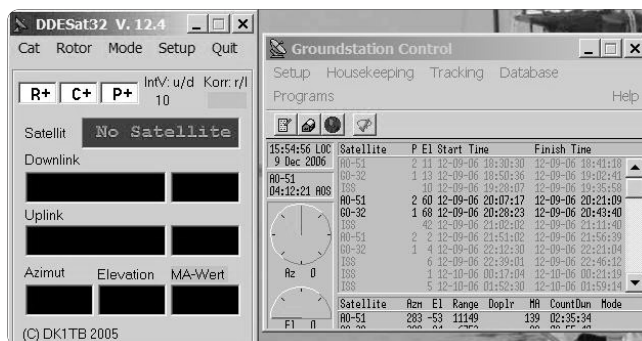
January/February 2007



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Cash Gifts

Visa, or MasterCard or checks are accepted. And, you can specify how your contribution is to be used.

Gift of Life Insurance

US taxpayers may be able to receive a significant income tax deduction by making The Radio Amateur Satellite Corporation the owner and beneficiary of life insurance policies.

Gift of Stocks or other Securities

US taxpayers should be able to avoid capital gains taxes on appreciated securities and receive a deduction for their fair market value.

Bequest

A codicil in your will, naming The Radio Amateur Satellite Corporation as a beneficiary will help insure the continuance of the Amateur Radio Satellite program.

Call the AMSAT-NA office at 301-589-6062 for questions on any or all of these ways you can help build new and exciting satellites.

Support AMSAT-NA

AMSAT Announcements

The Straits Area ARC Swap and Shop

When: July 14, 2007; 8:00 am - 12:00 pm

Testing at 12:30 pm

Where: Petoskey High School
Petoskey, MI 49770

Talk-in: 146.68- pl 110.9

Entry Fee: \$5 Tables \$10 and includes one door ticket.

Other: Door prizes, concessions, 50/50 drawing

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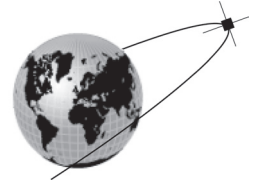
AMSAT's Mission

AMSAT is a non-profit volunteer organization which designs, builds and operates experimental satellites and promotes space education. We work in partnership with government, industry, educational institutions and fellow Amateur Radio societies. We encourage technical and scientific innovation, and promote the training and development of skilled satellite and ground system designers and operators.

AMSAT's Vision

Our Vision is to deploy high earth orbit satellite systems that offer daily coverage by 2009 and continuous coverage by 2012. AMSAT will continue active participation in human space missions and support a stream of LEO satellites developed in cooperation with the educational community and other amateur satellite groups.





AMSAT'S New Lab Taking Shape Eagle Satellite Construction Will Commence Soon

The Eagle satellite design is taking shape and 2007 will be the year when we begin construction of the space frame and electronic modules. To do this the satellite needs a home until it leaves for the launch pad. That home will be in the new AMSAT lab in Pocomoke City, Maryland on the Delmarva Peninsula near NASA's Wallops Island rocket launch facility.

After spending much of their holiday season packing up the remains of the old AMSAT lab in Orlando, Florida, AMSAT's VP Engineering, Bob McGwier, N4HY, VP Operations, Drew Glasbrenner, KO4MA, and AMSAT's new lab manager Bob Davis, KF4KSS, drove three large rental trucks 860 miles (almost 1400 km) up the East Coast to the new AMSAT lab.

They were met by an enthusiastic team of AMSAT volunteers on January 4, 2007 who began the process of unloading the trucks. The team consisted of AMSAT members David Bern, W2LNX, Robert Davis, KF4KSS, Drew Glasbrenner, KO4MA, Rick Hambly, W2GPS, Daniel Hykes, ex WB3DSP, Dan Schultz, N8FGV, Paul Shuch, N6TX, and John Williams, K8JW. Ken Blake and Hawk engineers Claude Treherne (who operated the fork lift) and Fritz Stapf also helped.

The next day a different team began the arduous task of inventorying everything that came off the trucks and comparing it to photo and spreadsheet inventories taken of the previous AMSAT lab in Orlando, Florida before that lab closed in August 2004. That team consisted of David Bern, W2LNX, Robert Davis, KF4KSS, Brian Gaffney, W3PU, Drew Glasbrenner, KO4MA, Rick Hambly, W2GPS, and Rob Renoud, K3RWR.

Since then, lab manager Bob Davis, KF4KSS, has been organizing volunteer teams with a well planned task list that includes 1) clean, refurbish, paint, repair and assemble the clean room, 2) sort and inventory hand tools, 3) apply inventory stickers to all AMSAT property, 4) repack items that are destined for long-term storage (like previous project documentation), 5) clean up two desks and the best two computers, and 6) discuss Eagle spacecraft with anybody that will listen!

Setting up this new lab and getting it into operation is a major undertaking for AMSAT but it will be well worth the effort. This lab will become the focus of our Eagle satellite integration and many other future AMSAT projects. I am looking forward to spending time working in this fine facility once we have the interior walls up and doors installed. AMSAT will have access to 8,000 square feet, which will consist of offices, meeting rooms, a clean lab and a machine shop.

As I outlined in the last *Journal*, AMSAT will share the space and some projects with the Hawk Institute for Space Sciences (HISS), a division of the Maryland Hawk Corporation, which is a 501(c) (3) non-profit educational organization, affiliated with the University of Maryland Eastern Shore (UMES).

Phase 3E Satellite Meeting in Germany

In January a meeting was held between representatives of AMSAT groups from North America (AMSAT-NA), the United Kingdom (AMSAT-UK), and Germany (AMSAT-DL) at the "Zentrales Entwicklungslabor für Elektronik", (Central Development Lab for Electronics, aka "The ZEL"), the P3E integration lab in Germany. We reviewed the progress of the P3E development and the status of the ZEL facility and have established an increased level of commitment to the project by AMSAT-NA and AMSAT-UK.

P3E is considered vital to the Amateur Radio space community for a variety of reasons. Currently there is no high orbit satellite carrying analog transponders allowing DX and multiple simultaneous contacts. The proposed orbit of P3E, like Eagle, will cause it to be in range of Amateur Radio stations on earth for several hours at a time allowing increased periods of operation and experimentation.

Although construction is centered at the ZEL, many of the components come from other parts of the world, including the Integrated Housekeeping Unit (IHU-3), the CAN-Do bus interface modules, the STAR camera from AMSAT-NA and the U/V SDX transponder module from AMSAT-UK.

P3E is considered a 'low risk' approach based on many of the design parameters

Apogee View continues on page 19 ...

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The AMSAT Journal (ISSN: 1407-3076) is published bi-monthly (Jan/Feb, Mar/Apr, May/Jun, Jul/Aug, Sep/Oct, Nov/Dec) by AMSAT-NA, 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703. Telephone: 301-589-6062, fax: 301-608-3410. Periodicals postage paid at Silver Spring, MD and additional mailing offices.

Postmaster: Send address changes to *The AMSAT Journal*, 850 Sligo Avenue, Suite 600, Silver Spring, MD 20910-4703.

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Why Can't I Hear AO-51?

by: Mark Spencer, WA8SME, mspencer@arrl.org

"So, Echo in FM mode will be easily workable on a dual band handheld with a handheld Yagi antenna. If the transmitters can be run at increased power levels, the Echo could be worked with "rubber duck" antennas." -- AMSAT Web site.

Operating the low earth orbit satellites (LEO), particularly AO-51 (AMSAT Echo) can be a very fun and satisfying activity. The LEO FM birds are relatively easy to access with simple and common ham radio equipment. However, authors have a tendency to over simplify the ease of access to the LEOs. There is a huge difference in the probability of success between the operating conditions depicted in the figures labeled 23.8 and 23.9 (from the 2006 ARRL Handbook).



Photo 1: W2RS shows another popular LEO FM antenna for handheld operations.

Also, if taken out of context, this statement from the AMSAT Web site could give the impression that an HT with rubber duck is all that is needed to access Echo.

The bottom line is that it is far easier to get your signal into the satellites than it is to hear the satellites. If you don't do your homework and try to access the satellites without the required equipment to hear the satellites, you will become frustrated because "no one is on the birds" or "no one is answering my CQ calls." The other users of the satellites in turn will become frustrated because their QSOs are being disrupted by your un-answerable transmissions that tie up valuable satellite access time. You need to hear the birds before you can use the birds and the simple vertical or rubber duck antenna that you use for repeater operations may not be good

enough to hear the satellites. In addition to the HT or other quality receiver, you need to consider an antenna with some directional gain, good quality low loss coax feed line and maybe even a receiver pre-amp.

The following treatise is an attempt to quantify, explain and help you understand the science of radio that is required to access satellites. I hope it will convince you to explore equipment alternatives that will allow you to reliably access the satellites and maximize your enjoyment of this operating activity.

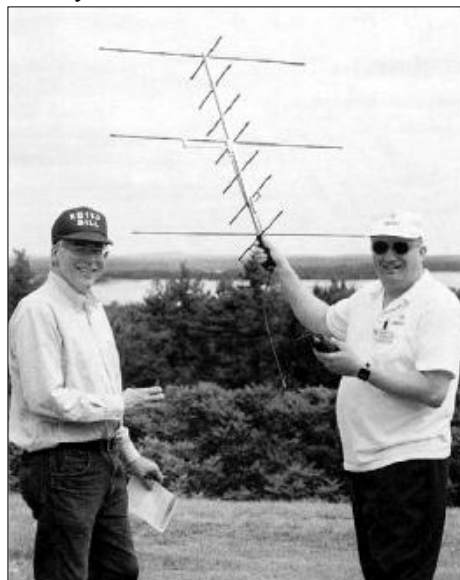


Photo 2: The handheld "Arrow gain antenna is popular for FM LEO operations. (Photo courtesy of The AMSAT Journal, Sep/Oct 1998.)

Satellite Path Power Budget

Some level of understanding of radio and mathematics fundamentals is assumed during the following discussion of power budget. If you need more detail, there are expanded explanations contained in the sidebars and also more information can be found in various ham radio publications.

To evaluate the kinds of equipment needed to make a successful satellite contact, we need to look at the gains and losses that occur along the path up to and down from the satellite. These gains and losses comprise what is called a power budget. If you think of the factors that impact a signal as it traverses between the satellite and your station, you will probably come up with a list something like this:

Gain/Loss factors in a satellite link path

- Transmitter power
- Feed line loss
- Transmitting antenna gain
- Path loss due to distance and frequency
- Path loss due to travel through ionosphere
- Polarization mismatch
- Receiving antenna gain
- Feed line loss
- Receiver sensitivity

These are just some of the factors that either add to (gains) or subtract from (losses) the signal between the satellite and your station. To make comparisons between gains and losses, we need to use a common set of units, and that unit is the decibel (dB). So let's take a look at each factor in the power budget in dB from the satellite down.

Transmitter Power: The Echo transmitter has a power output of 1 watt (high power mode, normal mode is 500 mw). This is actually a pretty hefty satellite signal. One watt equates to a power of +30 dB_m (+27 dB_m low power). Since this is our starting power level, it is considered a gain (+ sign).

Feed Line Loss: The satellite antenna and the satellite transmitter are very close together so we can assume that there are negligible losses in the feed line.

Transmitting Antenna Gain: Satellite antennas are generally small in size to accommodate the physical space constraints of the launch vehicle. Because of the size constraints and the need to cover a large surface area below the satellite, high gain is not the norm for satellite antennas. The Echo antenna is rated at +2 dB_i of gain.

Path Loss: A radio signal loses apparent strength as it travels out away from the transmitting antenna into space. The Friis equation is a way to quantify the signal strength at some distance of travel. To simplify the signal strength generated by a moving target (the satellite), let's calculate the path loss at the furthest point when the satellite just becomes visible over the horizon, and at the closest point. The path loss for 3,000 km of travel is -154 dB and the path loss for 800 km of travel is -143 dB.

Loss Due to Travel Through the Ionosphere: The path loss calculated above is just due to the spreading out of the available power over and expanding area

What are logarithms?

A logarithm, or log, is a mathematical technique to represent and manipulate incredibly large and/or incredibly small numbers. Any number can be replaced or represented by some base number raised to a power. For instance 10 raised to the power of 2 equals 100:

$$10^2 = 100$$

In the vocabulary of logs, the exponent 2 is the log, base 10, of 100. The number 10 in this example is called the base, or $\log_{10}$. There are two common base values used in mathematics, 10 and e. ("e" is the natural logarithm and has a value of 2.718281...) Using the vocabulary of logs, 100 would be represented this way:

$$2 = \log_{10}(100)$$

The log does not have to be a whole or integer number, nor does it have to be positive. For instance, .015 represented as a logarithm would be -1.82390....:

$$-1.82390 = \log_{10}(0.015) \text{ or } 10^{-1.82390} = 0.015$$

We would say the $\log_{10}$ of .015 is -1.82390 (the actual value goes on for an infinite number of decimal places so for practical reasons the number is rounded off). Negative logs represent numbers less than 1. There is one important $\log_{10}$ value to remember. The $\log_{10}$ of 1 is 0 (zero):

$$10^0 = 1 \text{ or } 1 = \log_{10}(1)$$

So why use logarithms other than a short hand way to represent very large or very small numbers? If we have a series of numbers, for instance gains and losses in a transmitting/receiving system, each successive gain or loss multiplies or divides the preceding numbers within the series to end up with the final gain of the system. If we use logs of the same base values to represent the numbers in the series, then because of the laws of exponents (logs are really just exponents), we can simply add the log values to accomplish the multiplication and division.

away from the transmitter in a vacuum, there are additional losses whenever the signal comes in contact with obstacles, like electrically charged particles that make up the earth's ionosphere. It is assumed that there will be a -1 dB loss as the signal travels through the ionosphere.

Polarization Mismatch: Satellite signals are generally right-hand circularly polarized. This is due in part to the stabilizing rotation of the satellite and Faraday rotation that occurs as the signals interact with the earth's magnetosphere. The signal polarization is not constant throughout the satellite passes so it will be assumed that there will be some polarization mismatch even if the receiving antenna is also right-hand circularly polarized. There is a -3 dB loss between a circularly polarized transmitting antenna and a linearly polarized receiving antenna.

The following table summaries the power budget from the satellite down to the receiving antenna. This portion of the power budget is out of your control and is a function of the satellite design and the physics of signal propagation.

Satellite TX Power	+ 30 dB
Feed line loss	0 dB
TX antenna gain	+2 dB
Path loss (3,000 km)	-154 dB
Ionosphere	-1 dB
Polarization mismatch	-3 dB
Total	-126 dB

The signal at the receiver antenna is - 126 dB.

Receiver Sensitivity: Most receivers specify the minimum signal required at the antenna jack to produce a minimally usable signal in the speaker. By convention, a 12 dB SINAD signal is considered minimally usable. This signal strength is probably not strong enough to break the squelch in your HT, therefore to hear a minimally usable signal you would have to manually open the squelch to hear the signal. A receiver sensitivity of .18μV is typical. This signal level equates to -122 dB_m.

Receiver Antenna Gain: Now we will discuss some of the station components that you have some control over. Let's assume that you are going to use a fixed station vertical antenna. The gain of this antenna is based on a lot of factors not to mention that the antenna is probably designed to work terrestrial repeaters located on the horizon and therefore the gain is optimized at the horizon. The typical gain of a simple ground plane antenna is around +3 dB.

Feedline Loss: Antenna feed line loss probably does not receive the attention it deserves. You would be amazed at the amount of signal that is lost in the antenna feed line. The following table summarizes the approximate loss of common coax types.

Approximate Loss in Coax at 430MHz		
Coax Type	dB loss/100 ft.	dB loss/50 ft.
RG8	3.08	1.54
RG58	10.7	5.35
RG213	4.6	2.3
LMR400	8.0	4.0
½ inch Hardline	1.4	0.7

Let's assume that you are using 50 feet of RG58 for your coax run, the loss would be -5.35 dB.

What is a decibel?

The decibel (dB) is widely used in electronics to compare power levels to quantify if there are relative gains or losses within a circuit. The dB is a logarithmic unit used to describe a ratio between the power level of interest to some baseline power level. It is convenient to use a baseline power level of one milli-watt or 0.001 watt in radio and satellite work.

The difference in dB between two power levels is expressed as:

$$dB_m = 10 \log \left(\frac{P_{watts}}{P_{reference \text{ milliwatts}}} \right)$$

or

$$dB_m = 10 \log \left(\frac{P_{watts}}{.001 \text{ watt}} \right)$$

Both power levels need to be in the same units. Positive dB_m would mean relative gain, negative dB_m would mean relative loss.

Because there can be different baseline references depending on the application, it is sometimes important to indicate what the reference units are. In this case, the reference is one milli-watt so the "m" subscript is added to dB_m. Another baseline reference you will see in this paper is dB_i. dB_i will be used when antenna gains are compared to the mathematically ideal antenna which is called the isotropic antenna.

Putting it All Together

The following table summarizes the power budget we have using a standard VHF/UHF ham station.

The net result is that you need -122 dB to hear the signal, but you only have -128.38 dB available. You will never hear the satellite!

Satellite TX Power	+ 30 dB
Feed line loss	0 dB
TX antenna gain	+2 dB
Path loss (3,000 km)	-154 dB
Ionosphere	-1 dB
Polarization mismatch	-3 dB
RX antenna gain	+3 dB
Feed line loss	-5.35 dB
Total	-128.35 dB

Now with the information in the basic power budget table, let's play with some of the entries to see what happens. First, will you be able to hear the satellite when it is overhead? Enter -143 for the pass loss, which adjusts the total to -119. So, yes, the received signal is a few dB above the minimum ... if we assume that the antenna gain is still 3 dB directly above, which is doubtful. But you might be able to hear the satellite for a few



Determining path loss with Friis equation

The available transmitted power is dispersed as if on the surface of an expanding sphere as it moves away from the transmitting antenna. Since there is a set amount of power being transmitted, as the wave travels further away from the antenna, this set amount of power is distributed over a wider and wider area. The Friis equation expresses the power level, in dB, as a function of the wavelength and the distance away from the signal source:

$$Loss_{dB} = 20 \log \left(\frac{4\pi d}{\lambda} \right)$$

We can use the Friis equation to predict the satellite signal power at the receive antenna, in other words, the loss in signal strength in dB as the signal travels through space. The units for wavelength and distance must be the same.

For example, when a LEO comes over the horizon, the distance between your station and the satellite is approximately 3000 km. If the downlink frequency is in the 70 cm band, the wavelength is .7 m. Plugging these values into the Friis equation:

$$154dB = 20 \log \left(\frac{4\pi * 3 \times 10^6}{.7} \right)$$

It is intuitive that there would be signal loss during the trip through space, the loss would therefore be -154 dB (rounded off).

For a second example, when a LEO is directly overhead, the distance between your station and the satellite is approximately 800 km. Using the same downlink frequency:

$$143dB = 20 \log \left(\frac{4\pi * 8 \times 10^5}{.7} \right)$$

The loss is -143 dB.

minutes of the pass.

Now try improving the coax from RG58 to RG8. Enter the loss of -1.54 dB and the total is -124 dB (at the horizon), still not quite good enough though there will be more reception time as the satellite gets closer.

Many satellite users are using a handheld Yagi antenna (like the one pictured on page 4) with good success. I have modeled this antenna and estimate the gain is approximately 10 dB_i. Considering that you manually point the antenna at the satellite, this gain should be relatively stable. So let's see what happens when using a handheld Yagi. Enter +10 dB for the receiver antenna gain and let's assume no feed line loss since the antenna will be handheld with an HT. The resulting signal at the radio is -113 dB, well above the signal required for the minimum! If we enter the path loss for the closest point of the satellite's approach, the signal is -102 dB, approaching full quieting.

If you want to receive the satellites with the same quality as you experience with repeaters, you would have to boost the signal at the receiver to approximately -94 dB. This would require the addition of a receiver pre-amp at the antenna. Most pre-amps will produce gains of between 12 and 15 dB. If you add the gain of the pre-amp to the power budget, the received signal is now -101 dB at the horizon and -90 dB overhead.

So from this discussion you should conclude that some antenna with gain, quality low loss coax and perhaps an antenna mounted pre-amp will help you at least hear the birds, if not being down right essential.

Why is it easier to hit the birds than receive the birds? To answer this question, let's take a look at the power budget for the uplink for the typical HT with rubber duck antenna using 2 meters for the uplink frequency.

Transmitter Power: Let's assume the typical 5 watt HT output power. That equates to +37 dB_m.

Feedline Loss: Zero, the antenna is mounted on the HT.

Antenna Gain: For a rubber duck antenna is actually a loss at typically -2 dB.

Path Loss: At 2 meters and 3,000 km path loss is -145 dB and at 800 km it is -134 dB.

We will use the same losses for polarization (-3 dB) and travel through the ionosphere (-1 dB).

Echo Antenna Gain: The same at +2 dB.

Echo Receiver Sensitivity: The satellite receiver is slightly less sensitive than your receiver at -125 dB for 12 dB SINAD.

Now doing the math, the signal at the Echo receiver is -112 dB, more than enough signal strength to be almost full quieting! So that statement about using an HT with rubber duck in the introduction is true, but only to transmit into the satellite, not receive the satellite. There also would be more than enough signal produced by the typical 50 watt mobile rig to hit the satellite with a simple vertical antenna, but you would not be able to hear the satellite.

Conclusion

I hope that you have found the discussion informative and I hope it will cause you to think about how you can improve your satellite receiving situation. I would recommend that you consider at least a modest gain antenna as a minimum,

Converting receiver sensitivity into equivalent power levels

Receiver sensitivity is expressed by the manufacturer as the number of micro-volts of signal at the receiver input to produce 12 dB of SINAD. (SINAD stands for signal plus noise plus distortion and is a measure of signal quality produced by the receiver's speaker.)

$$SINAD_{dB} = 10 \log \left(\frac{SND}{ND} \right)$$

Where SND is signal+noise+distortion and ND is noise+distortion

By definition, 12 dB SINAD is the minimally useful signal. An excellent signal would be 40 dB SINAD. We cannot use SINAD values directly in our signal path evaluation so we will need to convert the micro-volt specification to produce a 12 dB SINAD signal into dBm. My receiver specifies that .18μV will produce 12 dB SINAD. The standard input impedance of a modern receiver is 52Ω. Using Ohms law:

$$I = \frac{E}{R}$$

or

$$3.462 \times 10^{-9} \text{ amps} = \frac{1.8 \times 10^{-7} \text{ volts}}{52 \text{ ohms}}$$

and

$$P = EI$$

or

$$6.23 \times 10^{-16} \text{ watts} = 1.8 \times 10^{-7} \text{ volts} * 3.462 \times 10^{-9} \text{ amp}$$

Converting this power into dBm:

$$-122dB_m = 10 \log \left(\frac{6.23 \times 10^{-16} \text{ watts}}{.001 \text{ watt}} \right)$$

The power at the receiver input to produce the minimally useful signal at the speaker would be -122 dBm. To produce full quieting (FM), an excellent signal would require a power level of approximately -94dBm.

upgrading your feed line and adding a receiver pre-amp as your financial situation will allow. Don't automatically assume that you can fully access the LEO FM birds with the same station you use to access your local repeaters. Your HT and vertical antenna may allow you to transmit into the satellite but will not be good enough, except in the most extra ordinary conditions, to hear the satellites. A little thought, planning and understanding of the science of radio will go a long way into opening the satellites to you. 📡



Rotor and CAT Control for Satellite Tracking via USB Ports and Windows XP

Dieter Schliemann, KX4Y, kx4y@amsat.org

From following the *amsat-bb*, I got the impression that some ham radio satellite users believe that Wisp cannot run under Windows XP. I have had Wisp running my digital ham radio satellite station on Windows 2000 Pro for about two years now, by using my Kansas City Tracker/Tuner (KCT/T). I have that set up running in one of my P-266 computers.

ISA slots for use by a KCT/T are only available in old computers. Some new computers even come without a serial port (DB9 type COM port).

I want a ham radio satellite-tracking configuration that makes me independent of ISA slots and serial ports. I want to be able to run my station, as well as a portable station for ARISS school contacts, from my laptop computer. That requires that I need to be able to run all of my required satellite equipment from USB ports on any one of my computers. I would prefer being able to run my station's antenna and radios controlled by equipment via TCP/IP, i.e. my computer network (LAN) at my house, but I have not found equipment that lets me go that route. So, using USB ports on PCs is it for me for the time being.

I have used a KCT/T since 1988 when I first set up my station for ham radio satellite use. In 1988, I used my KCT/T in my XT computer using DOS. Over time using other computers along the way, my KCT/T ended up in one of my P-266 computers operating on Windows 2000 Pro (w2k). I have used my KCT/T with just about all satellite tracking programs including SatSked and Wisp, all available from AMSAT. I have been very happy with using my KCT/T. So happy, that I still have two new KCT/T spares. Unfortunately, these KCT/Ts require ISA slots.

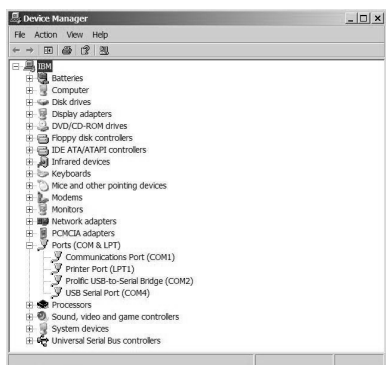


Figure 1

Lately, I grew tired of using a slow computer for my ham radio satellite use. When I saw the articles "Simple Satellite Tracker Interface for Yaesu G5500 or G5400 Rotors" by Mark Spencer, WA8SME, in the May/June 2006 and July/August 2006 issues of *The AMSAT Journal*, I decided to build two of these interface units. For pictures and information of the tracker, please see the above-mentioned Journal issues. My trackers came out to look exactly as shown by Mark Spencer.

I have been waiting for the tracker/tuner that Steve Bible, N7HPR, has been working on for some time. I had high hopes that we would be able to have TCP/IP tracker/tuner interface equipment that I could simply connect to my LAN, to get away from COM ports and such. But, it has not happened yet. So, using the Tracker developed by Mark Spencer for antenna control and using my ICOM CT-17 signal converter for radio CAT control, offered me an acceptable alternative for controlling my station. In fact, I am extremely pleased with the performance of the two trackers I built. They work great.

As mentioned above, I built two Trackers; one for use at my fixed station and the other one available for possible use with ARISS school direct contacts, i.e. with the satellite ground station at the school. I am working on acquiring a second complete satellite ground station for possible use at such contacts so that I don't have to take my home station apart for such events. Besides, I thought that building two of these trackers at the same time does not take very much more effort than building one only.

The tracker building instructions provided by Mark Spencer are excellent. I did not have any problems easily understanding and following his instructions. Mark also provided a complete parts list with part numbers and suppliers identified for building these units. Mark also provided information on how to configure SatPC32 for using this tracker.

Since the articles from Mark Spencer appeared in *The AMSAT Journal*, he has designed a printed circuit board for these trackers. (See page 15 of this issue - Ed.) Using his boards really simplified building my trackers. All components that have to be installed on the board are clearly identified on each board. It literally was plug-in and

play, provided one knows how to solder electronic components to a printed circuit board. For people who don't have good skills with that, Mark provided information on soldering techniques with his building instructions. Mark Spencer provides all of his building instructions for free on request and they also are being provided on the CD that he ships with the printed circuit boards that he supplies for a small donation to the ARRL educational fund.

My two trackers worked right off the bat. These trackers, if one installs all of the options, can be used connected to a PC – USB port, or one can connect them to a DB9 type COM port on a PC. I configured both of my units for use on USB ports.

My present satellite station configuration is as follows:

- ICOM-275H and 475H transceivers (still in use since 1988)
- ICOM - CT-17 signal converter with DB-25 serial port, connected to an USB port via a USB to serial port converter.
- Yaesu - G5400b AZ/EL antenna rotator
- Tracker connected to an USB port
- DSP-12 TNC with serial port connected to the DB9 COM1 port on my computer.
- IBM A30 PIII 1GHz Windows XP lap top computer
- Wisp32
- SatPC32 ver. 12.6
- DDESat32 ver. 12.4

Most of my ham radio satellite operation is by using the 9600-baud digital satellite GO-32. Never mind e-mail, I still like the digital satellites. But I have used LEO analog satellites and have communicated with the ISS. Like many of us, I am waiting for a usable HEO ham radio satellite.

Wisp has only a 16-bit driver (RR.DLL) to control the KCT/T for antenna rotator and

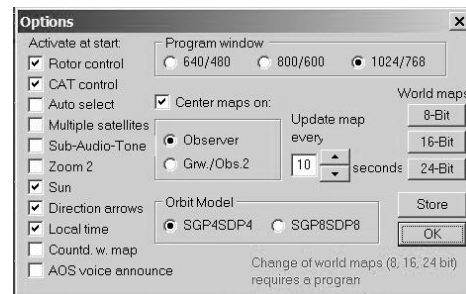


Figure 2



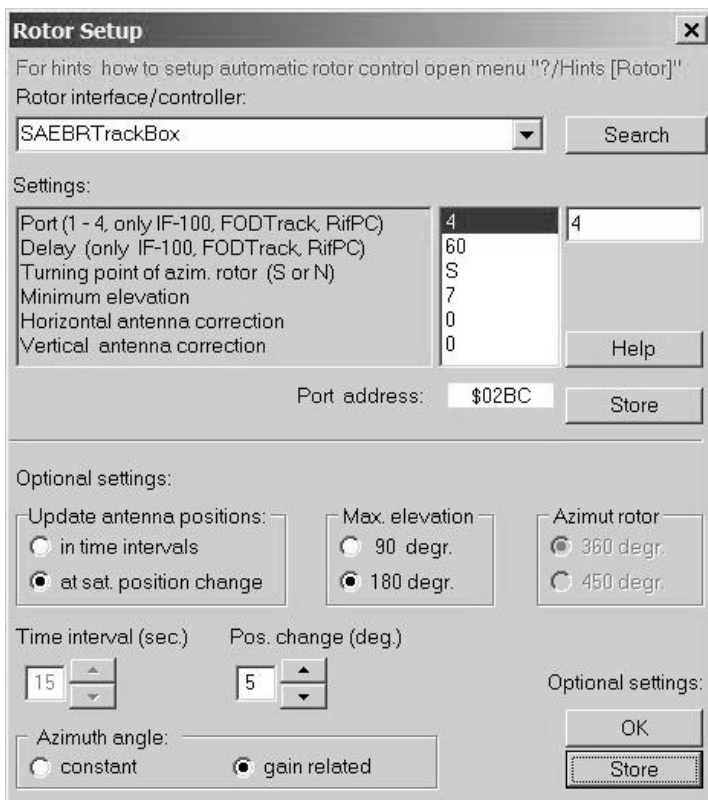


Figure 3

radio frequency (CAT) control. This driver works fine under Windows 95, 98 and ME, but not under NT (32 bit) based Windows such as NT 4.0, W2K or XP. Wisp can control the tracker by itself, but while using the tracker, won't perform rotor and CAT functions under Windows NT 4.0, XP or Windows 2000. These NT based Windows operating systems require hardware hooks that are only available in an operating system's kernel driver. (Thanks Erich Eichmann, DK1TB, for that explanation.)

To make satellite antenna tracking and radio tuning automatic in Wisp running on Windows 32 bit operating systems, requires the use of either a Wisp supported interface device that can do the tracking and tuning, or one has to use Wisp configured for the DDE

technical support. I appreciate his patience very much in getting me sorted out when I had silly questions.

For the digital satellites, I use Wisp32. But how to make Wisp control the antenna and the radios? I use DDESat32, a cousin to SatPC32, freely made available for use by Erich on his Web site <http://www.dk1tb.de/> to help Wisp control my station.

Before one can configure the needed programs for satellite communications, one needs to know the port numbers for all needed PC COM ports. To find out the COM port numbers for the tracker and my CT-17, I looked in Windows XP under start-settings-control panel-system-hardware-device manager and ports. For my system, it showed me the port numbers as shown in

mode while using another program in conjunction with Wisp to support that mode.

For use with analog satellites and the ISS, I very much favor SatPC32, a very nice and easy to use satellite-tracking program created by Erich Eichmann, DK1TB. I have used this program for a few years now. I like his program very much. I find it easy to configure and use. It gives me all of the features I need, and I don't remember it ever locking up on me. Besides, Erich provides excellent

Figure 1.

To connect the CT-17, I use an USB to serial port converter, which configured itself to COM2. My tracker, connected via a printer type USB cable directly to an USB port, configured to COM4. In my station setup, I made sure that I don't exceed the allowable length of USB cables. It is good practice to keep the USB cables as short as practicable. Personally, I would stay away from USB cables longer than 6 feet (2m).

I plugged my DSP-12 into the DB9 type COM1 connector on my computer, which always is COM1. With future computers, without available DB9 type COM ports, I'll use another USB to serial port converter for my TNC as well.

Knowing these port numbers used by the tracker and the CT-17 signal converter is needed for the configuration of SatPC32. The port number for the TNC needs to be known and set in Wisp.

To get the system configured, I started with SatPC32. Figure 2 shows my selections by going to setup and options in SatPC32.

Figure 3 shows how I set up the rotor control in SatPC32 by going to Setup and then going to Rotor Setup. Please note that the port number 4 is irrelevant in this Rotor Setup applet. It can be a different COM port number. In this applet, the port number applies only to LPT (printer) port; it does not apply to the SAEBRTrackBox interface.

By selecting "Setup" in SatPC32 and then selecting "Radio Setup", I selected COM-Port 2 and I selected ICOM for my brand of radio, as shown in Figure 4. By clicking on the arrows to the right of the radio selection, I made the selection for my radio model, the baud rate (same baud rate as my radios are set to) and I selected the addresses for my radios. I did not show these selections in this article, however it is quite intuitive what needs to be done once one reviews the setup panels.

After restarting SatPC32, it brings up the applet "ServerEasyComm1" as shown in Figure 5. In the ServerEasyComm1 setup, the COM port number must match the COM port assigned to by the computer, or manually modified for the tracker.

In Setup of "ServerEasyComm1" I made the selections as shown above and saved the settings.

DDESat32 Configuration

I downloaded DDESat32 from Erich

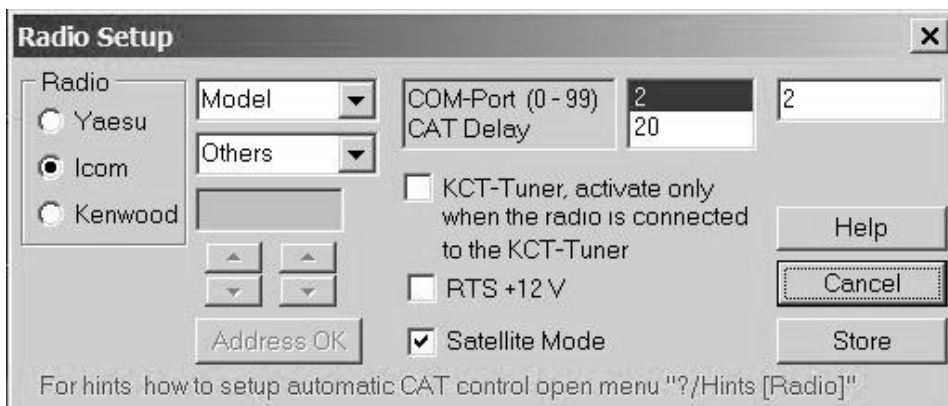


Figure 4

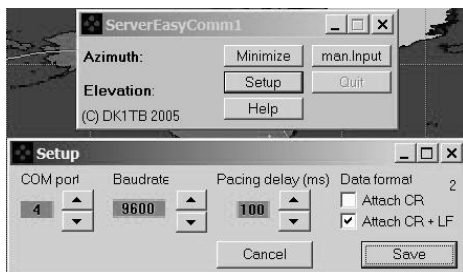


Figure 5

Eichmann's Web site <http://www.dk1tb.de/> and installed it in SatPC32 in accordance with the instructions associated with DDESat32.

Once DDESat32 is started, it brings up the following applet as shown in Figure 6.

DDESat32 also brings up Wisp as shown above.

In the DDESat32 "Setup" I made the selections for my station as shown in Figures 7, 8 and 9.

Wisp Configuration

Under the "Rotator" selection in Station Properties of Wisp, I selected DDE, my rotator's Stop Position and my preferred antenna park positions as shown in figure 10.

I am very pleased with the performance of my ham radio satellite antenna tracking and radio tuning control. It is great being able to use relatively fast computers now for my ham radio use. I also enjoy seeing the tracker's lights come on during antenna movements, in addition to hearing the relays click in my G-5400b controller. Building my two trackers and configuring the required programs was well worth my effort.

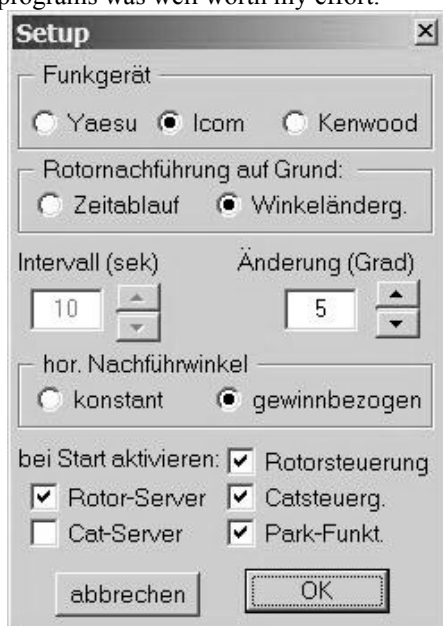


Figure 7

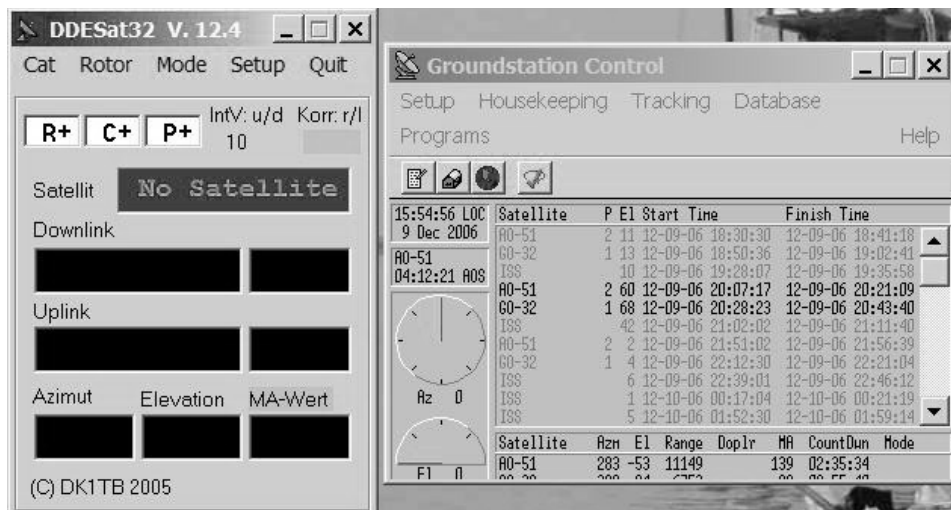


Figure 6

The following pictures show my ham radio satellite tracking station. As shown in Figures 11 and 12, I can use my laptop computer for rotor and CAT control, although I started out using one of my desktop computers first. The computer that I used first was a Dell, Intel P4, 2GHz with 1GB of RAM. I have used that computer as my main work station since 2001 until just recently when I replaced it with an AMD dual core 2 GHz processor computer with 1 GB of RAM as well. I keep both of these computers running on a 2 port KVM switch to avoid too many monitors and keyboards. Both of these desktop computers as well as my lap top computer are running on Windows XP Pro.

Having Wisp, SatPC32 ver 12.6 and DDESat32 ver 12.4 installed on my P4 desktop computer with the tracker, CT-17 and DSP-12 connected, gave me error messages every time after starting up that computer and bringing up SatPC32 or DDESat32. It told me that it could not open COM4 (for the tracker). Disconnecting and re-connecting the USB cable on the tracker made the system work reliably, until I re-booted that computer. That is not acceptable.

So, I created the identical Wisp32, SatPC32 and DDESat32 installation. I configured that computer with the same COM port numbers as I have used on my P4 desk top computer and connected the tracker to USB port COM4, the CT-17 to USB port COM2 and the DSP-12 to the DB9 type COM port 1, just as I used it on my desk top computer.

I got in and out of SatPC32 and DDESat32, without any error messages. Then I had AO-51 and GO-32 come by within just a few minutes of each other. I started DDESat32, which in turn started Wisp32. Everything

worked flawlessly. I am happy and re-learned a lesson that I had learned before. One cannot trust different computers to act identically using the same programs and configurations. My next step was to try out my setup on my AMD processor computer.

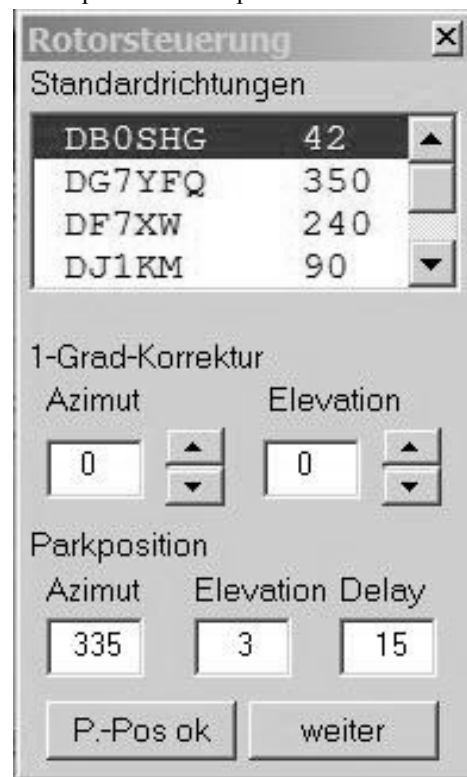


Figure 8

Again, to try things out with another computer, I duplicated my software installation and configuration on my AMD computer to be identical to what I have on my other two computers. I connected the tracker, the CT-17 and the DSP-12 the same way also, with the same port numbers as I used on the other two computers. This AMD computer that I put together from parts in an





Figure 9

old Dell tower case, has a 2 GHz dual core processor with 1GB of RAM. Figure 13 shows the three computers that I used for my three setups.

The dark computer below the light colored UPS is my P4 computer. To the right of it, is my AMD computer. By using a 2 port KVM switch, I share the monitor, keyboard and mouse with these two computers. It saves desk space.

After installing the software, configuring it and connecting the tracker, CT-17 and the DSP-12, everything worked right away with the AMD computer, just as it did with my laptop computer. With my laptop computer all set up of ham radio satellite operation, it gives me a good back up in case my AMD computer develops a problem. I believe in back up equipment. ☺

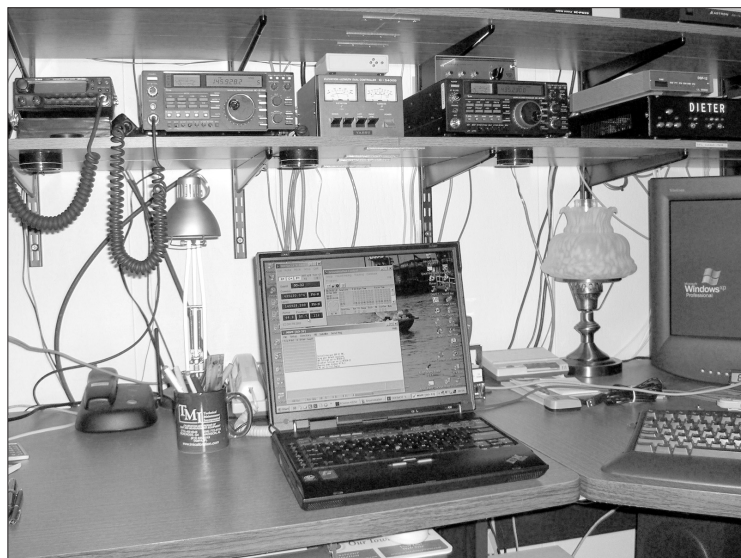


Figure 11

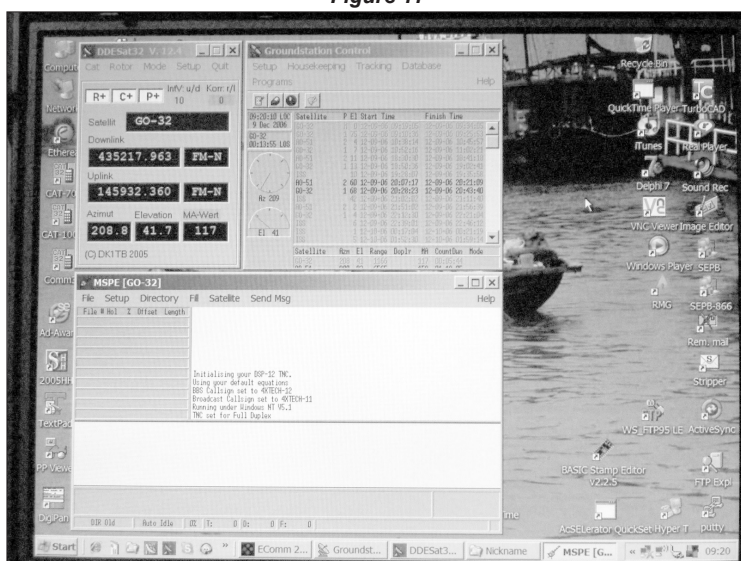


Figure 12

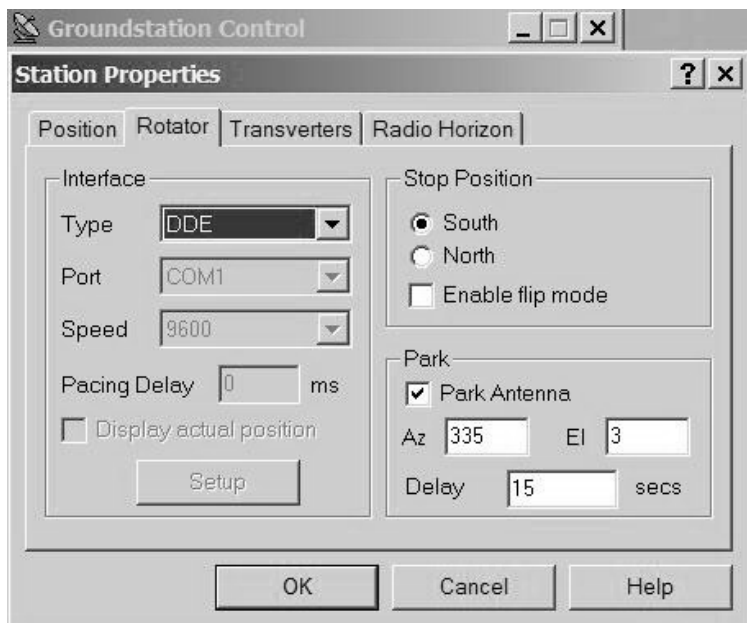


Figure 10



Figure 13

Pacific Ocean to Gulf of Mexico Ship-to-Ship Satellite Contact

by Andy MacAllister, W5ACM, and Allen Mattis, N5AFV

The first Amateur Radio satellite contact between a ship in the Pacific Ocean and a ship in the Gulf of Mexico took place on November 4, 2006. Andy MacAllister, W5ACM, was cruising on a ship in the central Gulf of Mexico in grid square EL54, while Allen Mattis, N5AFV, was located on a ship in the Pacific Ocean approximately 100 miles west of Ensenada, Mexico in grid square DM01. The two operators made contact on SO-50 at 1645 UTC.

Both W5ACM and N5AFV have experience operating from cruise ships (MacAllister, 1997 and 2000, Mattis, 2003 and 2005 (see references)), and they worked together in advance to plan this contact. In mid-



Photo A: Allen, N5AFV, found the sports deck of the ship to be a good operating position.

September Andy and Allen were talking at the weekly Houston AMSAT lunch and discovered that they would be on cruises at the same time. Andy would be sailing on a western Caribbean cruise out of Galveston at the same time Allen was sailing on a Hawaii cruise out of Los Angeles. In December 2004, Allen had previously made a ship-to-ship Amateur Radio satellite contact from grid square EK67 in the western Caribbean with John, N8QGC, who was on a ship in grid square FL51 east of Turks and Caicos. Allen and Andy decided to try to make an Amateur Radio satellite contact ship-to-ship from the Pacific Ocean to the western Caribbean or Gulf of Mexico.

The itineraries for the two cruises were compared and it was decided that the best opportunity for a contact would be when both ships were at sea because there would be no conflict with tours and sightseeing in the ports of call. In addition, both ships would have to be in the satellite footprint at the same time. Nova for Windows was configured to run two observers and one

satellite during the cruise period. It was found that the contact would have to take place in the window of November 2-4, 2006. Because AO-51 was not scheduled to be in V/U mode at that time, only SO-50 was available. Nova for Windows quickly identified the few satellite passes that met the criteria. Two passes of SO-50 were selected as the primary passes when the contact would be attempted.

The Western Front

The equipment used on the cruise ships for the satellite contacts in the FM V/U mode varied. Allen used an Icom W32A HT with a telescoping AL800 antenna. This combination makes an excellent portable satellite station (Mattis, 2005 (see references) and 2005 (see references)), and contacts have been made on satellite passes with extremely low maximum elevations with this equipment, thanks to the lack of obstructions when operating from ships. Allen has the distinction of being the second station to accomplish the "reverse" VUCC – operation from 100 different grid squares – all via hamsats.

On the Eastern Front

Andy, W5ACM, had a collection of radios and antennas for his cruise to the Gulf of Mexico and the western Caribbean. Hindsight is always 20-20, so the theory was that if you have more gear than you need, there will always be a way to make contacts if something goes wrong or is missing. The primary shipboard station consisted of an Alinco DJ-580T HT with a borrowed Arrow antenna from Tony, N5RPQ, and a set of earbuds. Other gear included a WA5VJB-design, five-element, 70-cm Yagi, telescoping AL800 antenna, Yaesu FT-817 transceiver, Yaesu VR-500 receiver, GPS receiver and a Palm Treo 600 with tracking software. Rather than traveling alone, Andy had some extra hams on board, including wife Heather, WB5RMA, Mike, WA5TWT, (previous AMSAT Awards Manager), John, WA5WOD, and Craig, WD5BDX.

While Allen, N5AFV, is known for operations both onboard and on land, Andy and his group could only operate while at sea due to the lack of licenses for the ports of call in Mexico, Grand Cayman and Jamaica. Excellent shore excursions and gentle pressure from non-ham wives were also a factor. The eastern group had two goals.

The first was to ensure that everything was ready for the scheduled contact with N5AFV toward the end of the cruise. The second was to experiment with the gear and antennas and have a good time.

Can you make shipboard contacts via AO-51 with SSB up on two meters and FM down on 70 cm? Yes, but it's not easy. The Yaesu FT-817 with the AL800 long whip provided a good uplink signal. For reception, the Yaesu VR-500 receiver was adequate, but the Alinco DJ-580T was somewhat better. The homebrew, five-element WA5VJB-design Yagi was excellent, and due to the small size and ease of use in the constantly windy environment of the cruise ship deck. Four contacts were made on two passes with three stations: W7JPI, N5UXT and KO4MA. Working with all of the different radios and antennas was difficult, but thanks to the efforts of Mike, John and Craig, the passes were tracked, the contacts logged and no gear or hams were lost over the side.

When AO-51 is not in the preferred V/U FM mode, what does it take to make successful contacts via SO-50? For N5AFV, the ICOM W32A with the AL800 antenna and an MFJ-288 headset are quite enough. He's done it thousands of times. The W5ACM crew discovered that the older Alinco DJ-580T was having problems with the signal level from SO-50. AO-51 is much louder (more output power) and the Alinco needed some help. This was the same HT that had been used nearly 15 years earlier for successful hand-held operations via AO-21 (also known as RS-14, RADIO-M1 and RUDAK-2) by W5ACM using the Diamond RH77B 15"-long antenna, earphones and separate microphone (MacAllister, 1992). After poor results on the first attempt with the Alinco and the AL800, Andy got the borrowed Arrow antenna up on deck for the next pass. Success! Signals were strong, easy to hear, and the antenna didn't show any damage from a few nearby poles and lifeboats that got in the way. There was even a contact with Bob, PJ4/K0NR, on the island of Bonaire (FK52) while cruising through grid EL-80.

The eastern W5ACM crew was testing gear during the SO-50 pass that was supposed to be too far to the east for Allen, N5AFV, out in the Pacific on November 4th. In the Gulf of Mexico it was one of those near-overhead passes with lots of Doppler, antenna work





Photo B: Eastern Crew – Mike, WA5TWT, Craig, WD5BDX, John, WA5WOD, and Andy, W5ACM.

and contacts. After QSOs with N3UNM, XE2AT and KC5TER, the crew was amazed and surprised to hear N5AFV/VP9 booming in. After smiles, congratulations (especially over the air to Allen), the eastern W5ACM crew finished the pass with six more QSOs including contacts with good friends Lou, W5DID, in Florida and John, K6YK, in California.

Back to the Western Front



Photo C: Andy, W5ACM/C6A, makes contact with Allen, N5AFV/VP9, via SO-50.

Allen, N5AFV, was in the satellite footprint before the W5ACM group on the 1645 UTC SO-50 pass on November 4, 2006. Allen worked a number of stations during the first part of the pass including K6YK, XE2AT, W6GMT, WI7P, N8BBQ and W0TUP and just as he was about to leave the footprint, he heard W5ACM calling him and quickly made the contact. Less than a minute later SO-50 was over the horizon - LOS, but the QSO had been successfully completed. W5ACM and N5AFV also made a contact on the following pass of SO-50 at 1828 UTC, but that contact did not generate quite

the excitement felt by the operators during that first memorable satellite connection.

Why it Worked

The effort to make this contact was successful for a number of reasons. Both Andy, his crew and Allen are experienced satellite operators and have experience operating on satellites from cruise ships. Prior planning, equipment testing and discussion played an essential role.

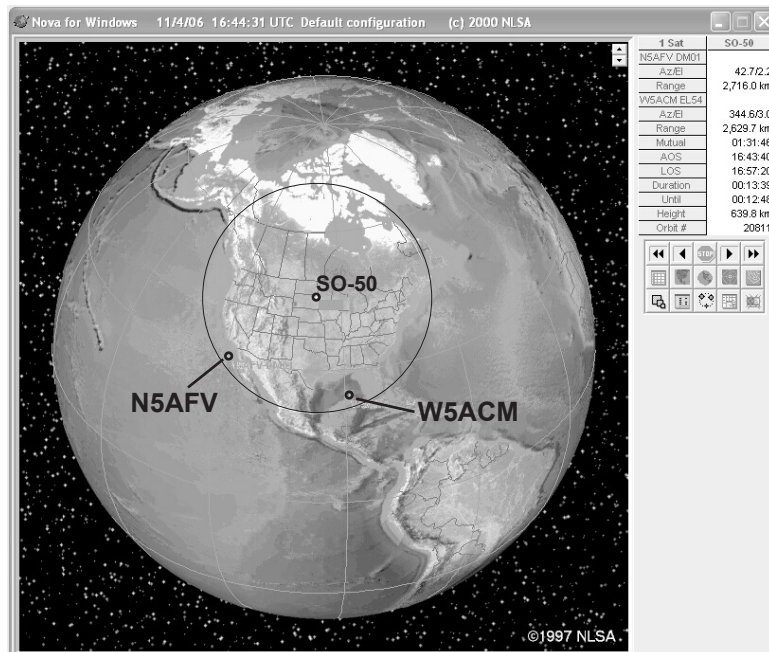
Orbital prediction programs were used to identify the passes that could be used for the contact and these passes were ranked and prioritized. Also, in finest tradition of Amateur Radio, the other satellite operators listening to the pass very courteously stood by while the contact was made.

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Photo D: Nova for Windows display of SO-50 footprint for 1645 UTC pass on November 4, 2006. (Editor's note: A small dot was added to this graphic to mark the approximate location of each ship. Since this is a black and white publication the marked locations are difficult to see.)



ARISS Contact from Streator, Illinois

by Steve Michalski, KB9UPS, kb9ups@excite.com

AMSAT Area Coordinator, Toledo, OH

AMSAT Area Coordinator, Streator, IL

This was my first school contact and I have a second planned with Challenger Learning Center of Lucas County in Oregon, Ohio. Nineteen students stood nervously as I, the control operator for the contact Tuesday morning, called the space station and promptly received a good signal back from Suni.

The schools first applied for the contact back in March 2003 and setbacks, both with NASA schedules and school schedules, constituted a long wait for contact day. Pam Riss, science teacher from Northlawn, was not optimistic that the contact would even happen, but could not hold back emotions as the voice of Suni Williams broke loudly over the speakers. Later Riss told local reporters "it's like a dream come true".

Students, teachers and invited guests had a great time listening to the students' questions and Suni's answers. Students asked questions like; "When you are on the shuttle going through the earth's atmosphere, do you control the Shuttle's rockets or do the people

on earth control them?" Suni's response was, "Well coming through the Earth's atmosphere that is all actually pre-loaded by the people on the ground. Once we get, on the what we call the heading alignment code that lines us up with the runway then the people in the shuttle fly the shuttle to the ground".

Another question was: "Can the ISS be hit by space debris and still be able to function?" Suni responded, "As a matter of fact, yes it can, but it depends on what size it is. Most of the material on the outside is made to protect us because they know that there is stuff floating around out here and so we are still able to function. However, if there are big pieces we're also able to maneuver and change our attitude to avoid it". The students enjoyed Suni's answers.

The nineteen students were selected by a school contest in which students submitted several questions through research, and teachers, Pam Riss of Northlawn and Nancy

Sedlacko of St. Anthony's, chose the best questions for the contact. Students also made many posters that filled the schools hallways. Special guests included, Streator's Mayor, Ray Schmitt and Illinois Senator, Gary Dahl. Technical advisor and ARISS mentor, Charlie Sufana, AJ9N, was on hand for the contact and said it was one of the better contacts he had seen.

As a member of the Starved Rock Radio Club, I created an eight person technical team from the club to serve as setup and operators for the contact. Although the contact took many hard hours of setup, everyone involved said it was all worth the hard work to see everyone have such a great time. Contacts with ARISS take as much as 700 to 800 hours of preparations by all those involved for the 10-minute contact with the station. I also have a contact planned from the Challenger Learning Center of Lucas County in Oregon, Ohio and have plans to contact several other schools in the Toledo, Ohio area and work with other groups in setting up for their contacts. ☸



1728 UTC - Two minutes and counting to AOS (acquisition of signal) of the International Space Station and students from Northlawn Junior High and St. Anthony schools in Streator, Illinois line up to talk to Flight Engineer Sunita "Suni" Williams aboard the ISS via Amateur Radio.



Streator Illinois students talk with the crew of the International Space Station January 16, 2007.



A Very Special

"Thank You"

For the Dollars & Effort

Gunther Meisse, W8GSM,
w8gsm@amsat.org
AMSAT Treasurer

AMSAT is pleased to announce that our membership has come through again contributing the necessary funds for us to achieve our \$150,000.00 2006 Financial Goal. The AMSAT Board of Directors Meeting decided to break down the Eagle fund raising goal into bit size amounts that our membership could support and which would give us a yearly sense of accomplishment. \$150,000.00 was the necessary number for the Eagle projects already committed for 2006 and early 2007. We got off to a slow start but following the Symposium in San Francisco the tempo picked up and we challenged the membership to put us over the top by December 31, 2006. You came through and we raised nearly \$157,000.00 for the year. These funds are going directly to the daily projects that the AMSAT volunteers have agreed to undertake making Eagle a reality. 2007 will also be a financially challenging year and we hope we can count on all of you for your continuing support.

In addition to much needed cash we count on AMSAT volunteers to provide hundreds of hours of dedicated service. To help us judge the degree of this volunteer effort a few years ago we established the VRS Volunteer Reporting System on the AMSAT Web site. Workers establish accounts and report their hours throughout the year. This year was a blockbuster with over \$567,397.00 worth of time donated. Another job well done! A special thank you to each one who worked so hard on behalf of AMSAT and the future of Eagle & P3E. 🌐



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Exciting new look!
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AMSAT is the North American distributor of **SatPC32**, a tracking program designed for ham satellite applications. For Windows 95, 98, NT, ME, 2000, XP.

Version 12.4 now supports Labjack U12 and W0LMD rotor controllers and Doppler tuning for Yaesu FT-817/857/897.

Features:

- Version 12.4 also supports automatic Internet download of Keplerian elements.
- Graphical tracking on a world map with two selectable Zoom factors.
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- Automatic rotor control support for: Kansas City Tracker/Tuner, FODtrack, Uni_Trac, SatEL, Labjack U12/Piggyback, W0LMD Mini/Junior/Senior Trackers, Yaesu GS-232, ARS from EA4TX, EGIS rotors, IF-100, RIF-PC, AMSAT-DL interface, WinRotor32, HalloRotor, and WiSP DDE clients.
- Doppler tuning with on-screen frequency displays. Radio models supported:
Yaesu FT-847, FT-736R, FT-817, FT-857, FT-897
ICOM IC-820H, IC-821H, IC-910H and other ICOM radios
Kenwood TS-790 and TS-2000
DDE client programs
- "Transparent" VFO-knob tuning in addition to keyboard and mouse tuning.
- "Virtual" VFO tracking for half-duplex transceivers FT-817, FT-857, FT-897.
- Includes a special version for ISS split-frequency operation.
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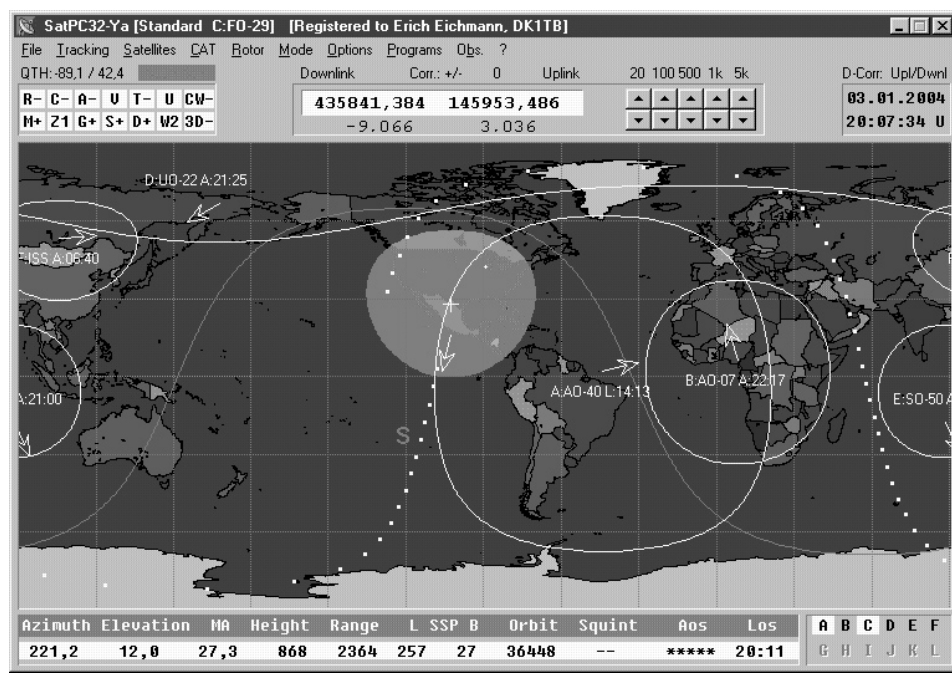
Price is \$45 for AMSAT members, \$50 for non-members, on CD-ROM.

A demo version may be downloaded from <http://www.dk1tb.de/indexeng.htm>

A registration password for the demo version is \$40 (members), \$45 (non-members).

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The author DK1TB donated SatPC32 to AMSAT. All proceeds support AMSAT.



Rotor Controller Boards Available

Hello All,

Thanks for your patience. I have procured the boards for the satellite tracker interface as described in the previous issue of *The AMSAT Journal* that you requested information about. I am offering this board at the request of many of you and loosely under the auspices of the ARRL Education and Technology Program (ETP). I originally developed this interface to help schools lower the cost of setting up a satellite ground station that meets the automatic antenna pointing criteria to qualify for an ARISS contact. I will be providing, initially, twenty-five of the interfaces to schools under the ARRL ETP grant program. I had a number of extra boards made up (75 to be exact) to meet the potential interest from the general ham population who might want to duplicate the project. I want to make it clear right up front, that this is not a profit making venture for me, all the money raised goes right back into the ARRL ETP funds to support the grant portfolio of that program (actually I hope that it will cover a substantial part of the cost of the interfaces that will go to schools).

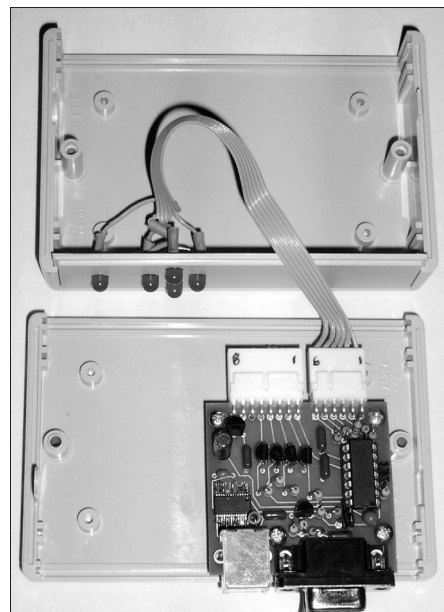
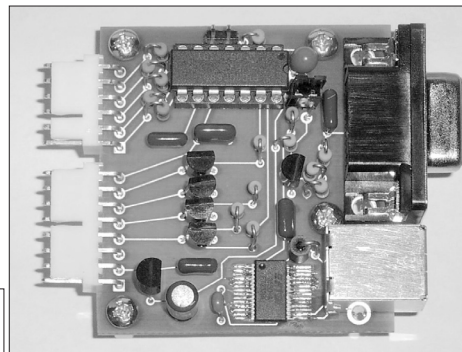
So after that lengthy preamble, here is the bottom line. For the price of \$25.00 you will receive the board, a programmed PIC, a CD-ROM with the construction manual, rotor and software set up information, parts list with Digikey numbers (except for the USB chip which is a Mouser number) and postage (within the USA). (The total cost of the project should be around \$45.00) For those outside the US, we'll have to figure

out a fair amount for postage. I am not set up to deal with anything other than checks or money orders, I don't have the capability to accept credit cards. Personal checks would be fine. Checks should be made out to ARRL ETP. If you throw in a few extra bucks, that would be a great way to support the education program.

Be aware that if you want to use the USB capabilities, the USB chip is surface mount. It isn't difficult, but it can be a challenge for the soldering novice. The board uses jumpers to select between Type 5500 and 5400 rotors and between USB and serial. If you are dedicated to one or the other, you can eliminate the appropriate parts from the project. I have attached a picture of the production board, and a few pictures of the completed project that will be given to schools.

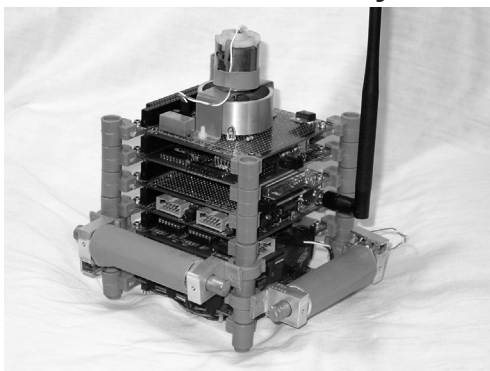
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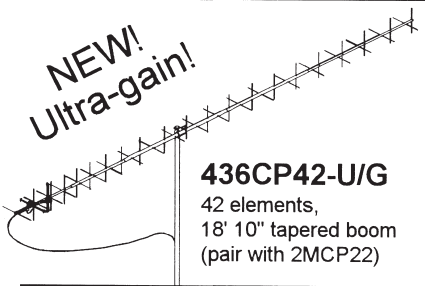
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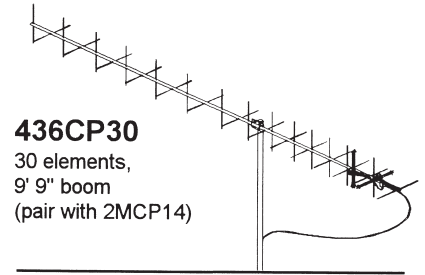


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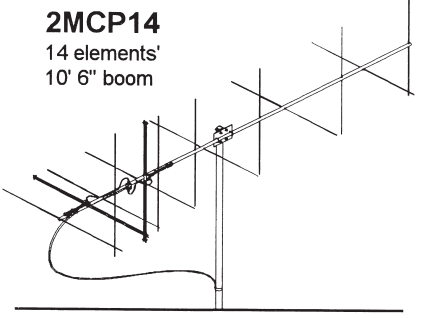
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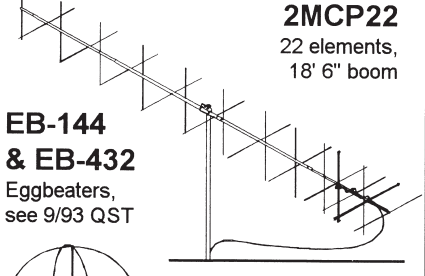
436CP42-U/G
42 elements,
18' 10" tapered boom
(pair with 2MCP22)



436CP30
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9' 9" boom
(pair with 2MCP14)

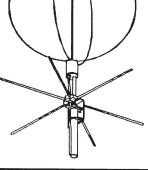


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The Orbital Classroom "Following Suit"

© 2006 by Dr. H. Paul Shuch, N6TX, n6tx@amsat.org
AMSAT Director of Education

No amateur satellite has captured the public imagination quite like SuitSat, the discarded Russian space suit that was tossed overboard from the International Space Station on 8 September 2005 stuffed full of ham radio equipment and dirty laundry. Proposed by Sergey Samburov, RV3DR, at the 2004 AMSAT Space Symposium near Washington, DC, this innovative project came together in a record eleven months and stands out as one of AMSAT's greatest educational successes. This, despite technical malfunctions that made the suit's 2-meter beacon almost impossible to copy, except by the best equipped, high-end ham stations. Nevertheless, students around the world were galvanized by an image evocative of a stranded cosmonaut (see Photo 1), giving Amateur Radio in general, and the ham satellite community in particular, an unprecedented foot in the classroom door.



Photo 1

Not ones to sit on their laurels, Sergey, Lou McFadin, W5DID, Frank Bauer, KA3HDO, and their ARISS (Amateur Radio on the International Space Station) team started right in on planning a sequel. As this column is being written, SuitSat2 is rapidly taking shape in a handful of laboratories and classrooms scattered around the US. But, unlike his predecessor, when this cosmonaut gets the boot, he should not whisper, but roar.

Nobody knows exactly why the original SuitSat's signals on Earth were several S-units weaker than planned. Speculation centers on malfunctions in the transmitter itself, the antenna and the coax that connected the two. Nevertheless, significant upgrades are planned this time around, involving more transmitter power, better coax, a new antenna design, a completely different power system (more about which later) and the use of Software Defined Radio (SDR) technology for the first time in an Amateur

Radio satellite. In short, this ain't your father's spacesuit.

The first SuitSat carried into space messages from students around the world. Some of these were the spoken word of greeting stored in digital memory and transmitted from orbit. Others were essays and pictures contributed by students to a CD-ROM attached to the suit's chest. Unlike the golden records carried into space aboard the NASA Voyager interplanetary spacecraft three decades earlier, this disk was never intended to be recovered and studied by intelligent extraterrestrials. Rather, it was our own terrestrial students who were given the opportunity to contemplate the kinds of messages they would most like to send off into space.

Looking beyond the first SuitSat, the successor spacecraft will carry not just student messages, but also student hardware and software into space. Much of the circuit fabrication and testing is being carried out in a Software Defined Radio course by a group of electronic engineering students at The College of New Jersey, Trenton NJ (see Photo 2). Under the leadership of adjunct faculty members Frank Brickley,

AB2KT, and Bob McGwier, N4HY, these undergraduates are gaining experience in producing real space flight-qualified hardware. What better motivator can there be for tomorrow's technological leaders? When the suit gets the boot, I'm sure they will be among the proudest youngsters on Planet Earth.

"Working with these kids has been one of the most enjoyable things I've done in quite awhile," writes instructor Frank Brickley, AB2KT, of his students at The College of New Jersey. "They seem genuinely turned on by walking the tightrope without a net as far as SuitSat is concerned. We will

all be doing a very good thing if we can continue to involve these kids, and more like them, in future AMSAT projects."

Frank emphasizes that the complexity of his students' project is not to be underestimated. "Since they're working with what is essentially the orbital design, there is nothing in the way of diagnostic hardware or software, which is why I described them as walking a tightrope without a net. Furthermore, given the complexity of what the SDR/SDX in SuitSat II will be required to provide, the applications will need to run in an unprecedented software environment: preemptive multitasking under freeRTOS. What the course comes down to then, is giving them a little verbal swimming instruction and then tossing them straight into the ocean. Rather than being intimidated, they all seem to be relishing the challenge and meeting it with obvious enthusiasm. Just the sort of attitude I have learned to expect during my association with AMSAT. Couldn't be a better match."

The first SuitSat burned up in the Earth's atmosphere just six months after orbital insertion, successfully completing its brief mission to boldly go where no suit had gone before. (As a teacher, I can't help but add: "to boldly split where no infinitive has split before".) SuitSat2 will follow in its footsteps, which means its mission too will be brief. But, because it carries panels of photovoltaic solar cells and a sophisticated battery charge regulator, this latest suit should transmit for the majority of its orbital lifetime, unlike its predecessor, whose (non-recharged) batteries expired after just a couple of weeks.



Photo 2



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- Design of Eagle Modules
by Dick Jansson, WD4FAB
- ARISS - Ten Years as a Team and Six Years in Space
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The power system is one area of focus for the College of New Jersey engineering students. Frank Brickle again: "In talking outside of class, a number of them have expressed real interest in power. It's not a subject covered anywhere in their curriculum. The biggest surprise about them as a group is how interested they are in taking a new approach to very basic, fundamental kinds of engineering issues and not necessarily the trendy, flashy topics. This is an unexpected source of optimism, for me, anyway."

Given the second suit's improved power system, we hope numerous students, in

classrooms widely scattered across our globe, will have the opportunity for multiple receptions and ongoing experiments. The more youngsters who can hear SuitSat's digitally synthesized voice, the more future space technologists we can claim credit for cranking out. And isn't that what AMSAT education is all about?

But, whether they hear a peep from SuitSat's transmitter or not, I expect thousands of students will be captivated forever by the image of the lonely astronaut, spinning away into the black void of space. If that isn't an educational message, what is? 🌐



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AMSAT at the Mesa, Arizona Hamfest

by Patrick Stoddard, WD9EWK/VA7EWK, wd9ewk@amsat.org

The AMSAT table at the Superstition Hamfest in Mesa, AZ was successful. There was lots of traffic by the table and good crowds for the two AO-51 demonstrations (1615 and 1755 UTC). I, along with Gerry, VE4GTB/KD7MDB, and Larry, W7LB, had a great time with an AMSAT table with AMSAT stuff along with the satellite demonstration(s) for the first time in at least a couple of years for a Phoenix-area hamfest. We also had some help from an AMSAT life member, George, W7ON, (my father-in-law), who lingered around the table striking up conversations and also answered questions from passers-by. AO-51 regulars Leo, W7JPI, and Ron, W6ZQ, stopped by throughout the morning. It was nice to have them make the drive from southern Arizona to the Phoenix area.

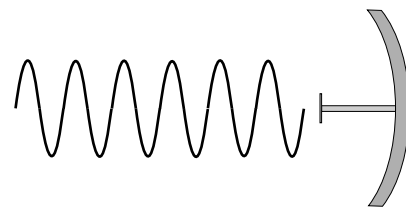
The first demonstration was a great AO-51 pass, at 1615-1630 UTC. With the satellite up to 80 degrees elevation, it was good for us with lots of activity across North America (10 QSOs). The 1755-1805 UTC pass, a westward pass with maximum 9 degrees elevation, was pretty good (3 QSOs, plus I heard a Mexican station toward the end of the pass that I could not make a contact with). My station was an IC-2720H mobile radio at 15W into my Arrow Antennas handheld dual-band Yagi (using a Diamond duplexer, to handle the higher power output).

From the radio's speaker jack, I strung an external speaker away from the radio for the crowd to listen to, along with a small earpiece so I could hear the radio and a Sony digital recorder to capture the activity on these passes (and log the contacts later). Larry, W7LB, listened to the activity with his FT-817 and Yagi, along with the crowd around the external speaker.

I had thought about trying at least one VO-52 pass during the hamfest, but never got around to it. We were talking with people for much of the morning; I didn't get my FT-817 out and try to work that satellite like I saw during the AMSAT demos at Dayton earlier this year. There will be other chances to do that.

We are planning to have an AMSAT table at three other Phoenix-area hamfests in the next few months and we will try to do demos on AO-51 provided the schedule is compatible with our equipment. Maybe other satellites, if those passes are compatible with these hamfests and the equipment we have. I'll post more information in advance of those hamfests, and hopefully we'll hear you during those demonstrations or see you at the hamfests.

73! 📶



Patrick, WD9EWK/VA7EWK, works the birds from the Meas, AZ hamfest while interested hams observe.



It's easy to set up an AMSAT booth. Contact Martha at AMSAT HQ for information on how to do it. Why not set one up at your next hamfest?

Apogee View - continued from page 3 ...

of the hugely successful OSCAR 13. To keep costs low, it is based on a flight spare chassis left over from the OSCAR 13 development program. There will, however, be several new innovations. For example, the Mode U/V transponder, with a planned 80 kHz bandwidth, will be based on DSP technology using software developed in the UK and SDR HELAPS jointly developed with AMSAT-NA. The IHU-3 will be a new development based on a unit successfully tested on OSCAR-40. Several other experiments will test techniques needed for the proposed flight of an Amateur Radio spacecraft to Mars (Phase 5A), for example, a low power beacon simulating the weak signals that it will send from the Phase 5A satellite (P5A) on its journey to Mars. This will allow radio amateurs to test their stations in readiness for P5A.

The optimal years for launching a Mars bound spacecraft are 2009 or 2011 so it is important that P3E is launched as soon as possible. This is currently planned for the end of 2008. It is realized that the next important step is to obtain an agreement with a suitable launch agency to undertake to fly the satellite.

AMSAT Needs You!

AMSAT needs your support to achieve our goals. Our Eagle satellite project is ramping up and our commitment to P3E is increasing. Please call the office or visit the AMSAT Web Store to make your donation to keep us going. All donations of \$120.00 or more qualify for President's Club status.

For information on setting up a hamfest AMSAT booth or giving presentations at local ham clubs, contact Martha at the AMSAT office (301) 589-6062 or your AMSAT Field Operations director, Gould Smith at WA4SXM@amsat.org.

73,

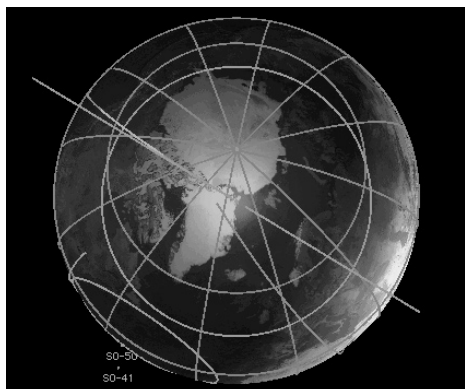
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Hot Rod Arrow

by Chip Olheiser, W7AIT, cwop@comcast.net

I was looking for a good satellite antenna design and researched antennas being used and built by others. I decided to try the Arrow antenna. What resulted after bench testing and some observations was a souped up or "Hot Rod Arrow". This article is a summary of my Hot Rod Arrow design. Refer to the pictures.



The antenna is fixed in elevation at about 20 degrees. It is only rotated in azimuth manually by an inexpensive TV rotor. The rotor has a digital rotor controller operated by a hand held remote. There is no provision for rotor computer control at this time.

How it Works

It has been found by others that 90% of LEO satellite orbits do not rise above 45 degrees at an individual observer's location. That is, 90% of the time ground station antenna pattern footprint elevations need be no higher than 45 degrees. The Hot Rod Arrow design meets this requirement. The antenna pattern cones are approximately 60 degrees. When mounted on the steel plate bent at 20 degrees, horizon to plus 45-degree coverage results. No elevation rotor is required.

There is a pattern donut hole - a drop out dead zone directly above the azimuth rotational axis. This dead zone or donut hole extends outward about 45 degrees as a cone around the azimuth rotational axis. Direct overhead satellite passes do drop out and are attenuated for about a minute or so when they hit this dead zone. Is this a problem? No! I just stop operating and wait until the satellite clears the donut hole. And remember, most passes are NOT directly overhead. Low elevation passes do not see this donut hole drop out.

Design

My design had to meet certain personal design criteria. These are:

1. Cheap. No expensive AZ/EL rotor or rotor interface.
2. Commercial off the shelf parts (COTS).

3. Not too complicated, can be moved relatively easily as in semi-permanent setup.
4. Withstand weather.
5. Excellent receive capability to be able to hear satellites horizon to horizon.
6. Excellent transmit capability without being an alligator station.
7. Easy to construct, assemble, test and use.
8. Meet AMSAT link budget performance parameters (see AMSAT "A Link Budget for AO-51", found on AO-51 page) for up and down link with S2 to S7 margins.

Antenna & System Hardware

1. MAST ROTOR ASSY: The Arrow antenna is mounted on a steel plate attached to a Warren Electronics/Radio Shack TV rotor assembly. The steel plate is fabricated easily from 18 gauge CRS steel and also has spare terminal block assembly for adding extra equipment later. The polarization should be set as shown (2 meter horizontal, 435 mHz vertical) so the antenna can be used for terrestrial use on 2 SSB and 440 FM without changing anything.
2. MAST: MFJ mast assembly is 1.4-inch diameter and directly accepts the Warren Electronics/Radio Shack TV rotor assembly. Mast should be painted

with extra paint to withstand weather. Nylon rope and cinderblock tie downs are used for wind survival.

3. MAST RX PREAMP ASSY: Two receive preamps with auto transmit RF sensing, 160 watts, are used for RX preamps. The preamps are 16 & 22 dB 0.5 db noise figure. These are made by Advanced Receiver Research and are the heart of the system. These MUST be mast mounted at the antenna. Do not scrimp on these if you build a Hot Rod Arrow or you won't receive. You'll end up being an alligator station and no one will like you. The ARR preamps are weatherproof and can be used without further weatherproofing.
4. MAST INTERFACE JUNCTION BOX ASSY: Interface control junction box, terminal block assembly and it's weather proof. This is a simple Radio Shack project box.
5. MAST DESENSE ASSY: 435 mHz desense is connected as in the AMSAT article "A Simple Desense Filter for ECHO and Other Mode - J Satellites" written by Anthony Monteiro, AA2TX, found on the AO-51 page. This helps reduce interference from the transmit signals and makes it easier to hear my own downlink signals before transmitting to others.





6. **COAX ASSY:** Low loss preassembled RF cabling used throughout; I used 9913 and currently have two separate 100 foot runs to the shack, connected to my TS2000X, with minimal loss. You **MUST** use good low loss coax for all runs and connections or this antenna will **NOT** work.



- RX amp and supplying bias voltages to the Amps. This is again built with a Radio Shack project box and uses simple toggle switches and 12-volt LED indicator assemblies to show which RX amplifiers are selected.
9. **SHACK, ROTOR CONTROL:** Rotor control, digital rotor controller part of

antenna match, verify and measure coax lines, testing transmit power at antenna feed point. A separate receiver is used to verify transmit signal quality and correct TX frequency before satellite AOS.



7. **CONTROL CABLING:** 14 gauge, 8 wire rotor cable is used to pass all rotor control and RF amp power and switching signals. The cable uses 7 of the 8 wires and has 1 spare wire for future use.
8. **SHACK RF RX AMP Control:** RF AMP switch box for selecting the appropriate

Warren Electronics/Radio Shack rotor. Rotor controller allows for full 360-degree rotation and 1 degree setting.

10. **SHACK ANTENNA SYSTEM CHECKOUT BEFORE SATELLITE USE:** SX-600 SWR/power meter for measuring SWR and transmit power. MFJ 600 mHz dummy load for testing

11. **COAX SEAL:** Use Coax Seal (not shown in pictures) to weatherproof all connections. The Comet 416 desense diplexer seems to be weatherproof, but you could seal it also to be sure.
12. **SHACK:** TS2000X, ASTRON RS7A for antenna system power, RX amp control switch box, SATPC32 Satellite tracking and control software.
13. **ARROW:** Remove and discard the stock Arrow diplexer, it won't handle power and degrades performance. Also tune the Arrow at 2 meter and 435 operating frequency to assure lowest SWR and optimum performance. Use the dummy load and SWR meter to make these adjustments.
14. **ARROW MOUNTING TO STEEL PLATE:** Use existing threaded $\frac{1}{4}$ - 20 mounting hole in Arrow boom.

Performance

The following numbers are approximate and are not guaranteed:

- Antenna System Beamwidth 2 meters: approx. +/-33 degrees
- Antenna System Beamwidth 435 mHz: approx. +/- 30 degrees
- Antenna System Gain 2 meters: approx. 7 db

- Antenna System Gain 435 mHz: approx. 10 db
- Antenna System front to back ratio 2 meters: approx. 18 db
- Antenna System front to back ratio 435 mHz: approx. 18 db
- Antenna System ERP 2 meters with 100 watts input: approx. 501 watts ERP**
- Antenna System ERP 435 mHz with 50 watts input: approx. 489 watts ERP**
- Polarization 2 meters: Horizontal (can be used for terrestrial SSB work)
- Polarization 435 mHz: Vertical (can be used for terrestrial 440 FM work)
- Polarity switching: None
- RX preamp gain 2 meters: approx. 22 db
- RX preamp gain 435 mHz: approx. 16 db
- Noise figure 2 meters: approx. 0.5 db
- Noise figure 435 mHz: approx. 0.5 db
- AMSAT Worksheet TX margins 2 meters: approx. 100 watts at antenna S2- S5 at satellite**



- AMSAT Worksheet TX margins 435 mHz: approx. 50 watts at antenna S2 - S5 at satellite**
- AMSAT Worksheet RX margins TS2000X with ARR preamps: approx.

2meters S2-S9+30

- AMSAT Worksheet RX margins TS2000X with ARR preamps: approx. 435 mHz S2-S9+30
- RX amplifier type: ARR MOSFET, RF switched, 160 watts TX
- Donut Hole drop out on overheads: Approximately 45 degree cone around zenith
- Rotor speed: 360 degrees in 1 minute
- Rotor setting resolution: 1 degree
- Rotor setting accuracy after calibration to true North approx.: +/- 10 degrees
- Satellites successfully worked: AO51, FO29, AO7, VO52, SO50*, ISS
- Satellite modes successfully worked: SSB, CW, FM, PACKET 9600b
- QSO's with hand held's: Kenwood THF6 stock 5 watts TX

* using FT897 transceiver

** CAUTION! Extreme RF fields – stay clear when transmitting. Also not recommended transmitting to satellite at full power, use minimum to establish communications (FCC regulations), else satellite overload could result.



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Conclusion

This picture article describes a moderate performance satellite antenna that is easy to build from commercial off the shelf hardware. It has provided me with many hours of Amateur Radio satellite communications. If you are interested in building one of these antenna systems, you may contact me at cwop@comcast.net for further construction details. ☎



AMSAT Eagle Update

by James A. Sanford, PE, WB4GCS, wb4gcs@amsat.org

Eagle Project Manager

Our Vision is to deploy high earth orbit satellite systems that offer daily coverage by 2009 and continuous coverage by 2012...

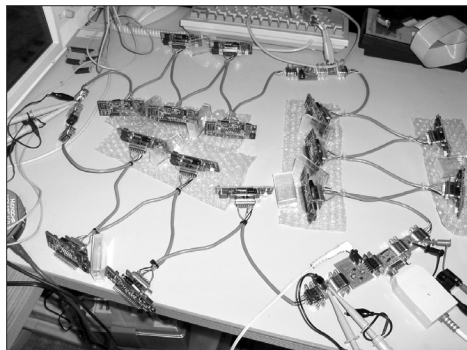
I hope that each of you had a very good holiday season, and wish all a happy and prosperous 2007. The New Year looks exciting for Eagle.

First, some details on the IHU-3 and CAN work session in November at the QTH of Lyle, KK7P:

- The new IHU PC-board was tested
- Memory issues were resolved, and IPS (the programming language used) now loads from on-chip memory, mass memory and EDAC (error detection and correction) memory
- The ring topology of the CAN bus works lowering power consumption and adding fault tolerance for up to 2 cuts in the bus (see the photo of a test setup)
- The A to D system has been selected and tested, allowing coding of the SDR command decoding to begin
- Telemetry ports have been tested
- The "emergency" port has been tested

Stephen Moraco, has made some great progress on a very affordable controller for the CAN bus. This will allow many of us to experiment with controlling the CAN-Do! widgets from PCs, at a much lower cost than purchasing the commercial units currently available. The first photo shows a prototype and the second shows the "ring bus" under test.

I was thrilled to read in Rick Hambly's President's Letter that the fund-raising goal for 2006 had been met. I suspect that effort was aided by end of year publicity in *QST*, *CQ* and *CQ-VHF*. We are getting the word out, and it is good that we met our funding goal. If you were one of the contributors, thank you! If all goes as planned we will spend some significant funds on **construction and testing** this year.



Alan Bloom's sensor team and Mark Raptis' Guidance, Navigation and Command (GNC) team have begun earnest discussions on the sensor package and the systems, which will use their data.

We have finalized the 70cm receiver design. John Stephenson, KD6OZH, is laying out a PC-board. Juan Rivera, WA6HTP, has assembled a team to build and test the prototype. Juan has also written an Acceptance Test Plan (ATP), which is posted on EaglePedia. I have convened a peer review of the ATP, which will proceed in parallel with construction of the first prototype.

Bob McGwier, N4HY, reports significant progress on a 2m transmitter design. More details will be provided on that in a future *Journal*.

Just before the New Year, Bob Davis, KF4KSS, Lou McFadin, W5DID, Stan Wood, WA4FNY, and Drew Glassbrenner, KO4MA, packed up all the equipment in storage in Florida and drove it to the new lab and integration facility on the eastern shore of Maryland. Rick Hambly, W2GPS, and Tom Clark, K3IO, helped unload, inventory and set up. We are going to have an excellent facility for development and integration of Eagle.

We have insisted from the outset that Eagle is an open project. To expand the pool of talent and inject new thinking, we have decided to change our peer review process slightly. As each peer review is convened, I'll send a request through AMSAT News Service and other channels for an at-large member of the review team. We will seek an AMSAT member volunteer who has background and experience related to the subject at hand. I will ask volunteers to provide a resume or other listing of related experience. I will then select one volunteer to augment the review team. In this way I hope to spread the workload, engage AMSAT members at large and perhaps recruit some new members of the Eagle team!

Finally, the New Year is traditionally a time of introspection and goal-setting. I spent a few minutes over the last few days developing a small set of personal goals for Eagle 2007:

- Prototype and demonstrate the 70cm receiver
- Prototype and demonstrate the 2m transmitter
- Demonstrate the above with some SDX prototype
- Finalize the IHU3 design and CAN bus (ring) topology
- Complete the structure redesign and build a model
- Refine the microwave phased array antennas
- Peer review, test and demonstrate the text messaging protocol and system
- Develop a detailed Work Breakdown Structure (WBS)
- Use the WBS to develop a construction schedule
- Begin development of integration and integrated test plans

This is an ambitious set of goals, but I think it represents where we are. I have asked the Eagle team to comment and add to these goals. Over the next few months look for a "final" set of 2007 goals to be posted on EaglePedia.

Finally, I want to thank Gould Smith, WA4SXM, for all his help. He has been a real workhorse for AMSAT and has been invaluable in helping the Eagle team with documentation. He's also helping us get the word out. If you've read and liked any of his many publications, drop him a line and let him know.

As always, questions and comments to, wb4gcs@amsat.org

73,

Jim



Bringing Space into Your Classroom

by Mark Spencer, WA8SME, mspencer@arrl.org
ARRL Education and Technology Program Coordinator

Space borne technology affects many things in our daily lives from telephone and television communications, to national security, to scientific research, to weather forecasting, to protection and husbandry of the environment and natural resources, to providing the location of your car when you have a flat tire and need help. It is important for our students to study space and space borne technology so that they can use this technology more effectively to enrich their lives. Also, if you are looking for something that cuts across curricular lines, something that connects multiple content areas from geography and geology, from physics and environmental studies, from the science of radio to the science of space ... bringing space into your student's learning experience just might be for you. I suspect that you think that bringing space into the classroom has to be expensive and requires advanced and sophisticated equipment, but you would be wrong. My purpose in this article is to illustrate a four-step approach that will allow you to bring space into your student's learning experience incrementally, at a level of rigor that is appropriate for your student, and at cost that is certainly affordable.

The four incremental building blocks that you can use to bring space into the classroom include:

1. A computer and satellite orbit prediction software

2. Adding a receiver to receive signals sent by satellites
3. Adding display software that will display imagery sent by certain satellites
4. Adding a dedicated satellite receiver and antenna for a quality satellite ground station

Step 1

Bringing space into your classroom begins with obtaining a computer and installing satellite orbit prediction software so that satellite positions and tracking are displayed in the classroom. The computer doesn't have to be the latest and newest, high-powered computer. Many older models that have been retired will do just fine. Satellite position prediction is fundamental to using space borne technology and provides many learning experiences for students. Predicting satellite locations used to be done with tedious mathematic calculations, but for years, computers have been used to do the chore. Some of the more capable prediction software packages can be purchased for modest costs but many free computer programs are available from Web resources and are for various computer platforms. [1]

When you have the computer with the satellite prediction software loaded just follow these steps to get started:

Update the computer's internal clock to the correct time. Though not absolutely necessary, the correct time is required for accurate position predictions. [2]

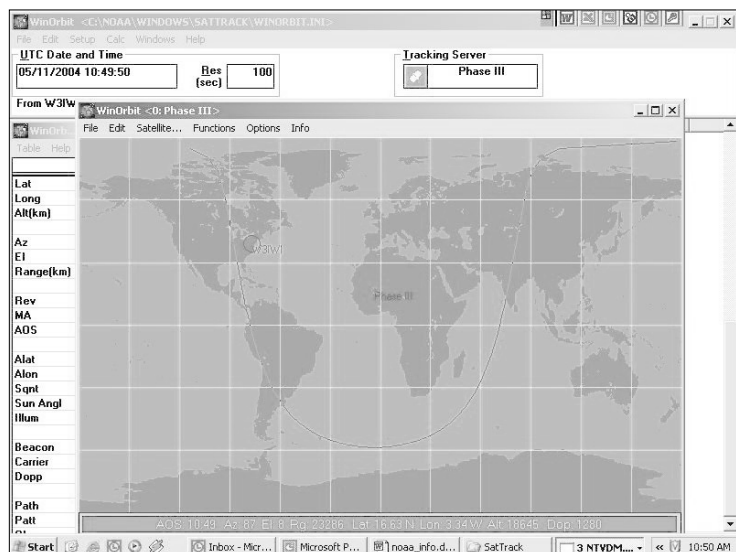


Figure 1: The typical display of orbital predication software. This is a freeware software package showing the orbit and position of a satellite.

international space station (ISS) and Hubble space telescope are interesting to students, but also there are NOAA low orbiting weather satellites, ham radio satellites, Global Positioning Satellites and others that will interest students. You might have the students select a satellite as "their" satellite and have them research and write a report on their satellite. You might consider choosing satellites in different kinds of orbits so that the students can learn why various orbits are used to accomplished different tasks or satellite missions.

Once the system is set up, just let it run. It does not require on-line access, the software and computer operate stand-alone and the computer continuously calculates the selected satellite positions and updates the computer display. Figure 1 is an example of the type of display that you can expect from free satellite prediction software. The software that I recommend is called NOVA, but it costs around \$50. The graphic display is more detailed and there are other valuable tracking features. Figure 2 is an example of the type of display using NOVA.

Many students have the impression that satellites orbit the earth in a wavy or sine wave motion because this is how satellite orbits are typically displayed. However, the satellites actually orbit in an elliptical orbit (almost circular) and the earth turns underneath the satellite as it orbits. On a flat map display, this results in the apparent sine-wave track. One feature I like about the NOVA software is that you can select a view of the earth from space, which gives a more 3-D view of satellite orbits (see Figure 3). In this view the students can see a more realistic orbital track, and the fast forward button advance the satellites in quick time to better illustrate the orbital track.

There are a number of learning topics that can be addressed by this first step in bring space into your classroom (see Table 1).

Step 2

Many of the satellites send out signals on frequencies that can be received on a commonly available public service (police) scanning receiver. In particular, the NOAA low orbiting satellites send out very strong and distinctive signals on frequencies 137.50, 137.62, 137.10 MHz. In this step,

Update the Keplerian elements. The Keplerian elements are the mathematical parameters used by the formulas in the predication software to calculate the satellite position. Up to date Keplerian elements are available from Web sites. [3]

Select the satellites you would like to track. The



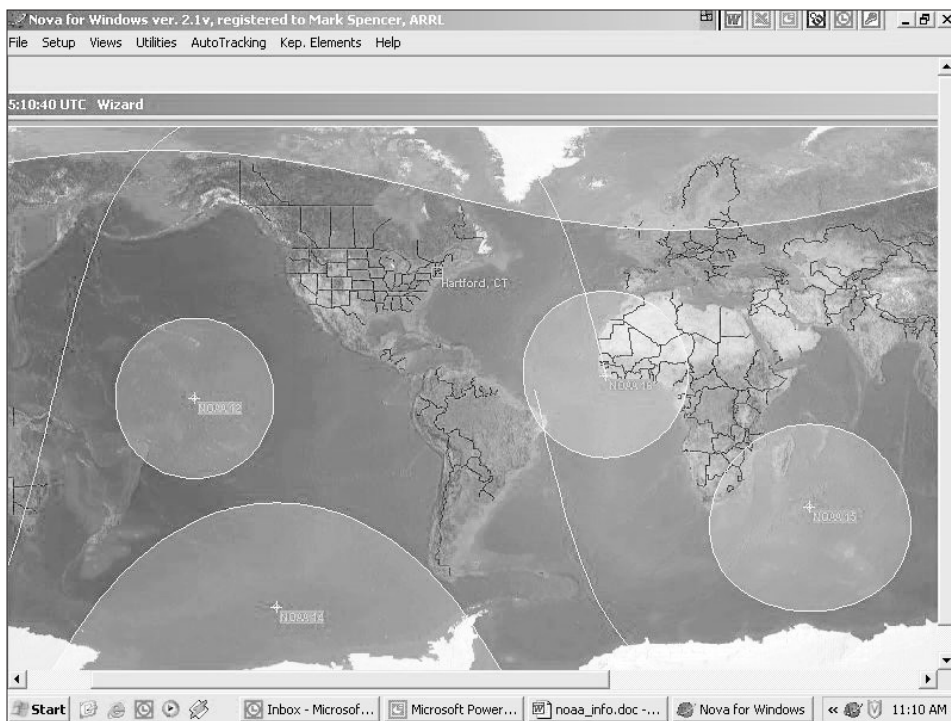


Figure 2: The display of satellite positions and orbits using a program called NOVA.

simply place a police scanner that is tuned to the appropriate frequencies next to the computer. An outside receiving antenna helps, but it is not necessary for this step. When the NOAA weather satellite comes within range of your classroom, the students will hear the bing-bing-bing of the satellite come up out the receiver background noise, and as the satellite goes beyond the horizon, the bing-bing-bi.... will stop. The satellite sends a weather picture using the varying audio tone that sounds like bing-bing-bing.

With satellite signals as a backdrop, the students can now learn about satellite hardware and sensors, how they are powered, what information they collect, how is that information sent down to earth, where are these satellites looking and why, and more. Table 2 illustrates just a small sample of the instructional concepts that can be covered with listening to signals from space.

Step 3

Now this is where bringing space into your classroom starts to really get exciting. In this step you add some display software that will take the bing-bing-bing and turn it into pictures of earth that are transmitted by the satellites in space. Sure, there are lots of weather images available from the Web, but there is nothing more exciting, nor satisfying, than receiving the pictures directly from the satellites as they pass overhead! And I can't believe that the imaging software is free!

To display satellite imagery you will need a computer with more capability than required in Step 1, but the computer needed is becoming the standard computer now days and you may already have the computer in your classroom. Download a program called WXT0IMG (which stands for weather to imagery) from the site on the Web. [4] You can purchase an upgrade for the WXT0IMG software if you desire, but the

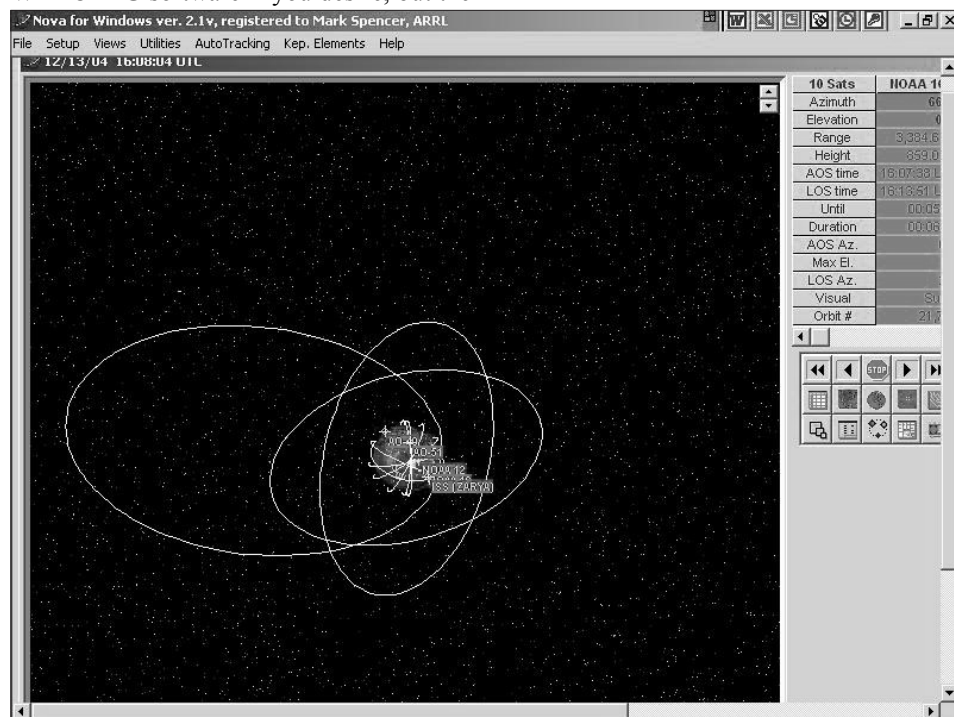


Figure 3: Three-dimensional view of orbits using NOVA software. This gives the student a different, and more realistic, perspective of satellite orbits.

free version provides ample capabilities for your students. Once the software is installed and set up (with your location and updated Kepler data), connect the receiver audio to the computer sound card. Now when the satellite is within range, the bing-bing-bing will be translated into a weather picture, line-by-line. Figure 4 shows an example of a weather image received this way.

For various reasons, which could be discussed with your student and are excellent learning opportunities, the police scanner is not optimized to receive signals transmitted from space and the resulting imagery is degraded. However, the imagery is very useful to show the student what is actually being collected by the satellite and transmitted. An image using the visual spectrum is sent side-by-side with the image using the infra-red spectrum. The WXT0IMG software adds the map display that provides excellent reference points for the imagery. Your location would be displayed with an "X".

Now with this imagery in your student's hands, they can explore the environmental sciences along with the physical sciences and physics of space borne technology. Table 3 lists just a few of the instructional concepts that can be added in this step.

Step 4

Because of the science of radio signals that originate in space from transmitters moving at high speeds, the signal characteristics

Table 1: Instructional Concepts for Step 1	
1. Geography	10. Kinds of Orbits
2. Geopolitical Boundaries	11. Argument of Perigee
3. Periodicity	12. Argument of Apogee
4. Map Projections	13. Descending/Ascending Nodes
5. Line of Sight	14. Elevation
6. Acquisition of Signal	15. Inclination
7. Loss of Signal	16. Increment
8. Location of Satellite	17. Etc., etc., etc. ...
9. Satellite Track	

Table 2: Instructional Concepts for Step 2	
1. Frequency and amplitude modulation	7. Signal acquisition
2. Amplitude versus gray scale	8. Signal strength
3. Video synchronization	9. Signal fading
4. Digital encoding	10. Signal polarization
5. Timing pulses	11. Path loss
6. Doppler shift	12. Etc., etc., etc., ...

require receiving equipment designed for the purpose. Though you can hear the satellite signals with a simple police scanner, Doppler shift and signal bandwidth requirements degrade the quality of the signal received with a police scanner (understanding both of these concepts are good learning opportunities for students). With a little investment in a receiver designed to receive satellite signals there is dramatic improvement in the quality of the signals received and the real power of the WXTOMG software and satellite pictures really comes into focus. A satellite receiver isn't as expensive as you might think. The typical receiver (an example is depicted in Figure 5) costs approximately \$250. An outside antenna designed specifically to receive signals from space also helps improve signal quality. I built a very good antenna from parts available from the local hardware store (shown in Figure 6). [5] A local ham radio operator could be a valuable resource to help with antenna construction and station set-up.

With quality signals, the imagery displayed by WXTOMG is top notch. There is a ton of information now at the student's fingertips (or mouse pointer) to be explored. There are readouts of latitude, longitude and temperature at the location beneath the mouse pointer. The imagery can be enhanced to emphasized different phenomena such as sea-surface temperature, precipitation, vegetation, visual or infrared spectrum, etc. Additionally, the imagery can be displayed with different map projections or sequential images can be combined to create a composite mosaic of images covering a greater geographic area. The potential for study and learning with this tool is without limit. The accompanying Figures 7 through 13 illustrate some of the potential learning opportunities available to you if you bring space into your classroom. Let your student's imagination dictate what they can do with the images they get from space through their satellite station.

Available Resources

There are some very good resources available to help you bring space into your classroom. An excellent on-line (and free) curriculum resource is located at: <http://octopus.gma.org/surfing/space.html>. There is a very good on-line course that can be used in your classroom that is located at: http://rammb.cira.colostate.edu/visit/topic_sat.html and <http://cimss.ssec.wisc.edu>.



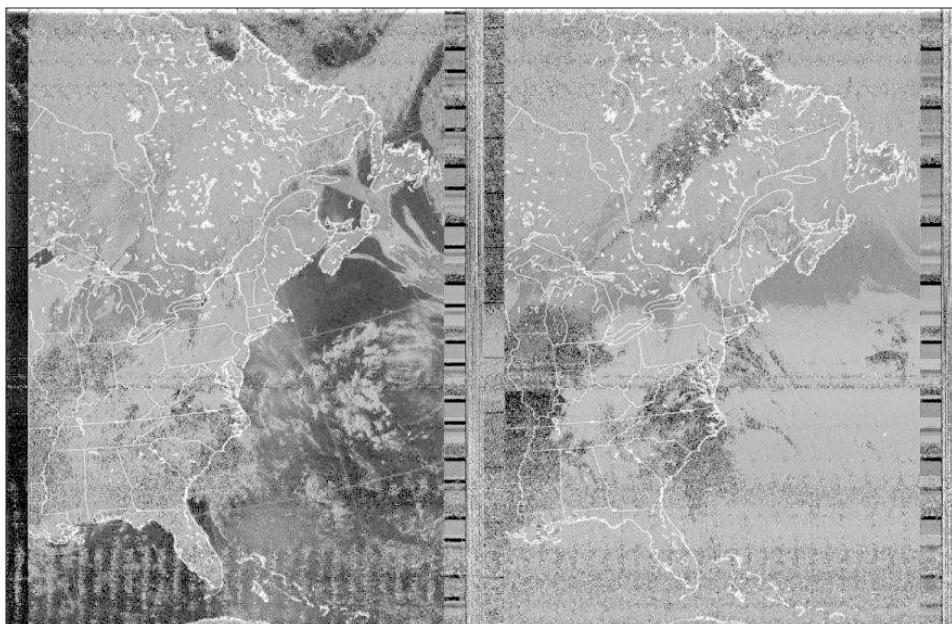


Figure 4: The imagery received using a police scanner receiver. The visual and infrared images are displayed side-by-side. Noise, static, and degraded signals prevent clear images, but the images are usable for instructional purposes.

[edu/satmet/CourseInfo/about.html](http://www.arrl.org/satmet/CourseInfo/about.html). There are free resources available to help with basic electronics, wireless technology and the science of radio at: <http://www.arrl.org/FandES/tbp/> and <http://www.arrl.org/FandES/tbp/Curriculum-Materials.html>. You are also invited to contact the author and request a CD-ROM packed with resources that will stimulate ideas to bring space into your classroom. The author can be contacted by mail: Mark Spencer, WA8SME, ARRL Education and Technology Program Coordinator, 774 Eastside Rd., Coleville, CA 96107; by e-mail at m Spencer@arrl.org or by phone (Pacific Time Zone) 530-495-9150.

References

- [1] DOS Satellite Tracking Programs: <http://www.amsat.org/amsat/ftpsoft.html#pc-trk> Windows Satellite Tracking Program: <http://www.amsat.org/amsat/ftpsoft.html#win-trk>
- [2] Update computer clock to correct time: <http://www.boulder.nist.gov/timefreq/service/its.htm>
- [3] Update software with current Keplerian data: <http://www.space-track.org/perl/login.pl>
- [4] Download display software from: <http://www.wxtoimg.com/>
- [5] Ralph E. Taggart, *Weather Satellite Handbook*, 5th Edition, American Radio Relay League, Newington, CT, ISBN: 0-87259-448-3, pgs. 2-9 through 2-11.



Table 3: Instructional Concepts for Step 3

1. Geography	8. Resolution
2. Geology	9. Gray scale
3. Geo-political boundaries	10. Calibration curves and data
4. Remote sensing	11. Latitude/longitude
5. Weather phenomena	12. Bandwidth and data throughput
6. Infrared spectrum	13. Map projections
7. Visual spectrum	14. Etc., etc., etc., ...





Figure 5: Example of a dedicated satellite receiver.



Figure 6: A simple, but effective, satellite receiving antenna can be made from materials purchased from your local home improvement store. The antenna is unobtrusive, lightweight and easily installed on a rooftop.

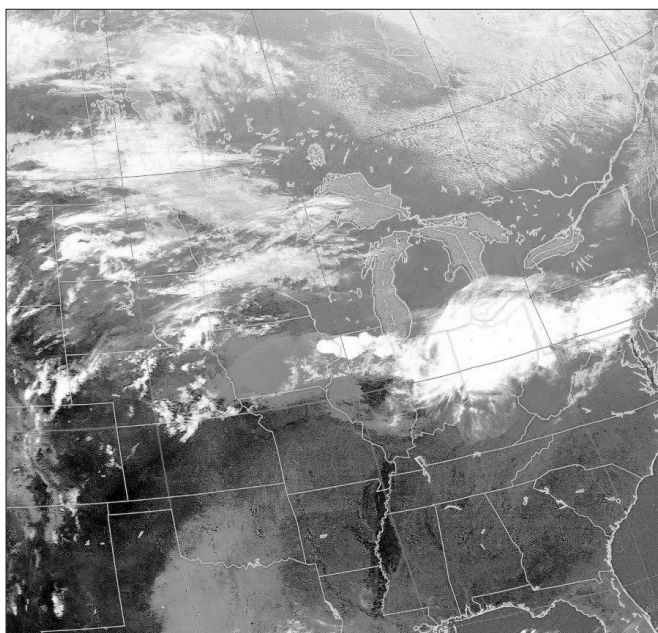


Figure 7: The imagery produced with a satellite receiver is a big improvement over the police scanner. The WXTOIMG software produces a multi-spectral display and colorizes the imagery for better interpretation. Here the oceans are blue, vegetation green, and various cloud levels shades of gray through white. Note the cloud mass over Ohio.

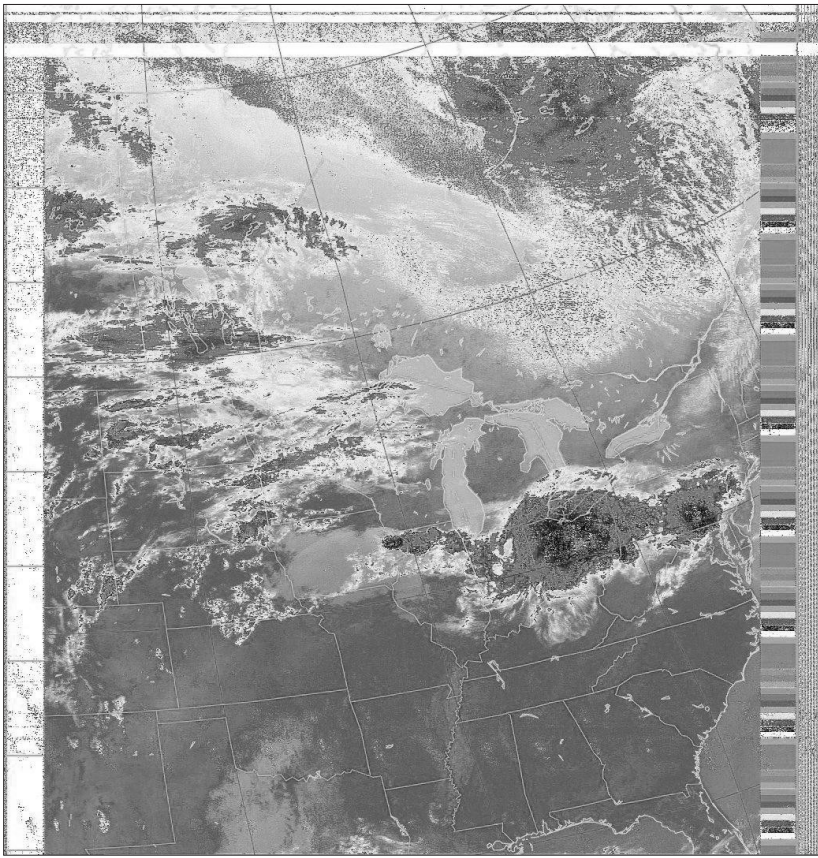


Figure 8: The same image with areas of precipitation enhanced. Note that those clouds over Ohio are actually some very intense thunderstorms.

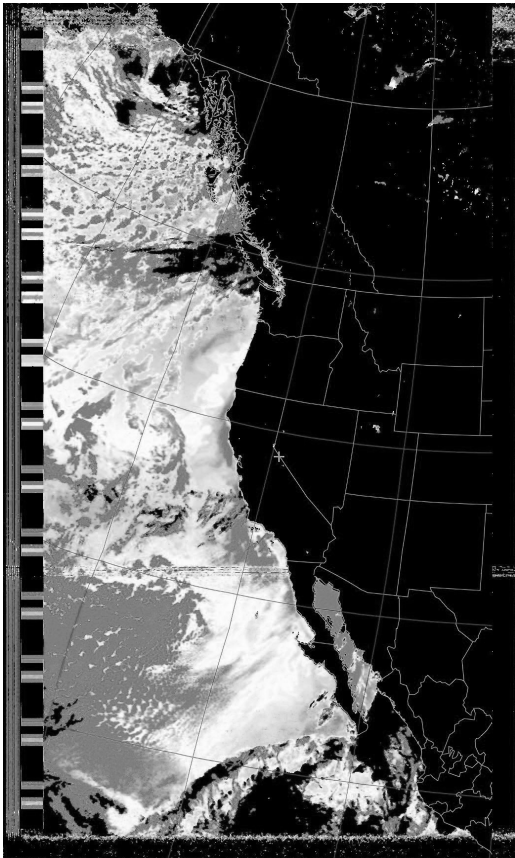


Figure 9 (right): This imagery on Thanksgiving shows a band of snow cover over Illinois and Indiana from a passing cold front. Placing the mouse cursor over the snow covered area showed the surface temperature to be near zero degrees centigrade, cloud cover is typically well below zero degrees centigrade.

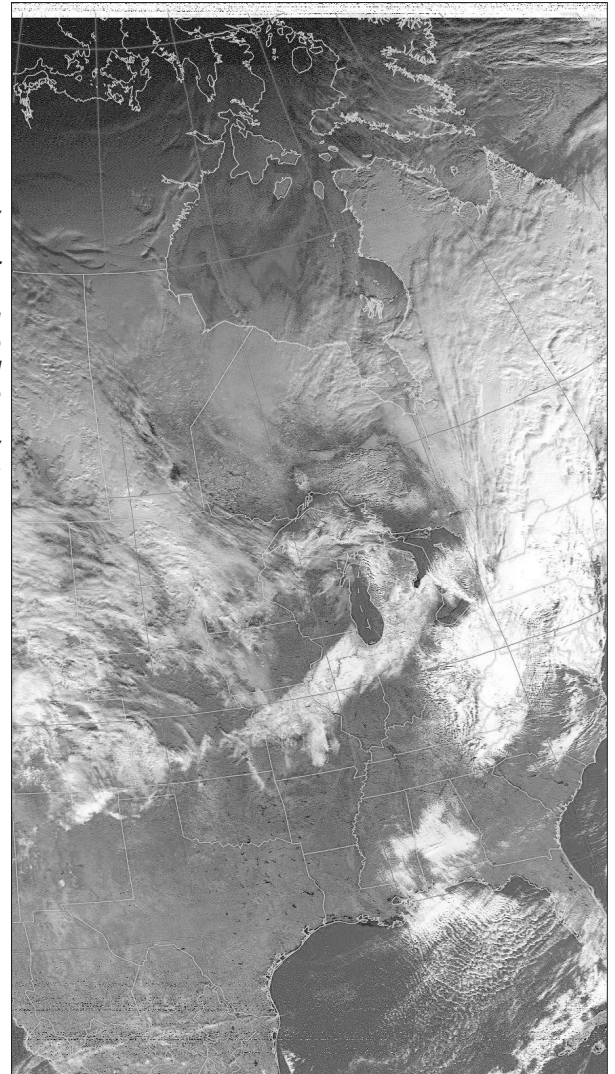


Figure 10 (left): A west coast image with sea-surface temperature enhancements. Notice the warm water in the Gulf of Baja (hard to see in black and white - Ed.). Students can plot sea currents by using the temperature measurements under the mouse cursor.

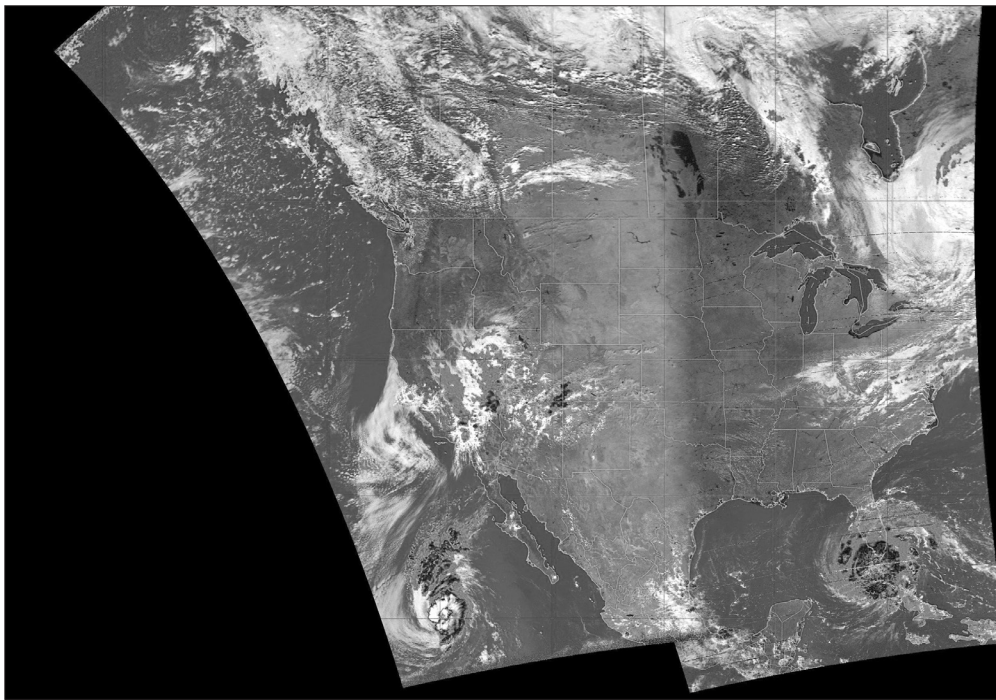


Figure 11: This a composite image produced by combining an image received on the east coast with one received on the west coast. Notice that there are two hurricanes at the same time. The shading difference is caused by different receiver settings.

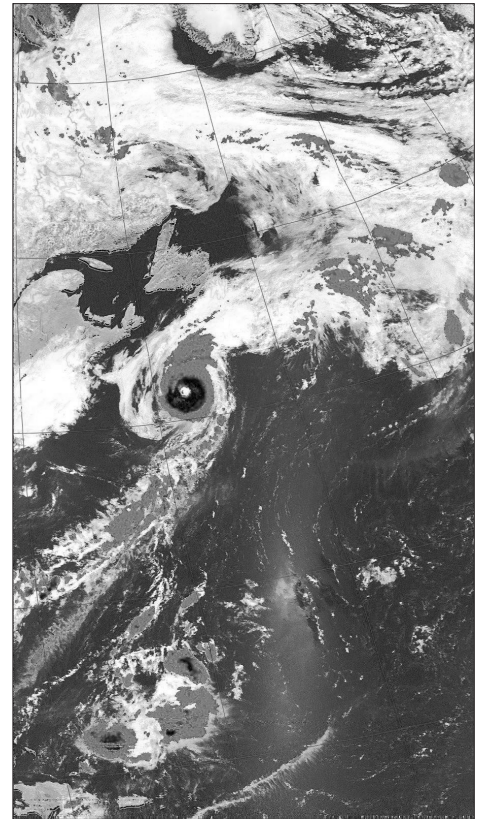


Figure 12: This is an image of a hurricane off the coast of Nova Scotia. Though over cold Atlantic waters, the hurricane is still intense as indicated by the prominent eye. Also note the vertical, bright area in the middle of the image. This is sun glint off the ocean surface, one way to explore angle of incidence and angle of reflection using the sun and the earth's surface!

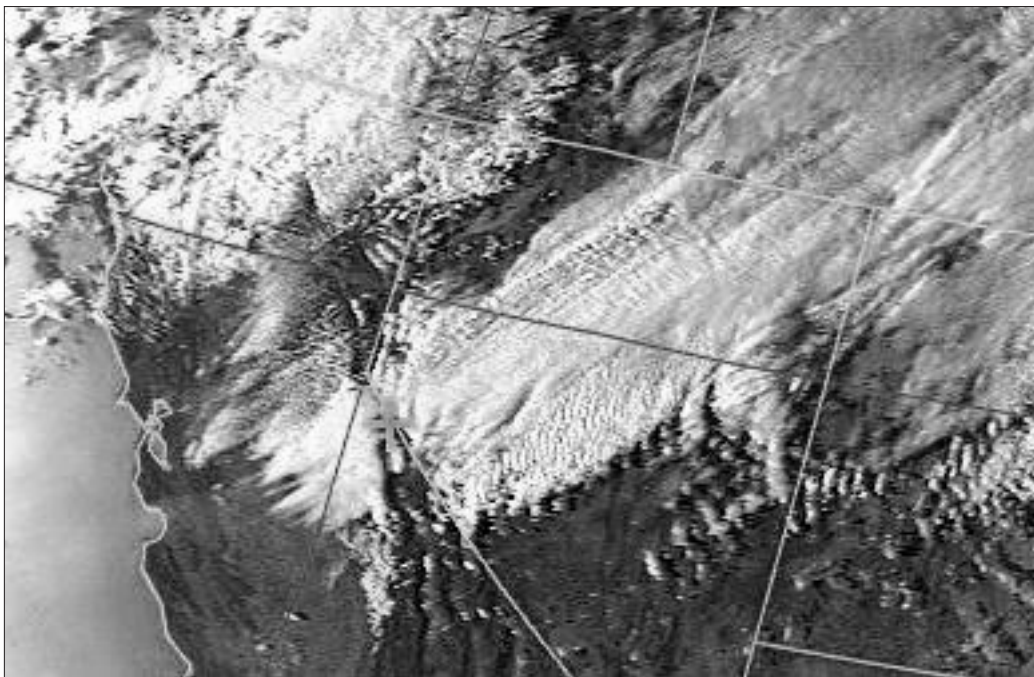


Figure 13: This enlarged image shows a more local weather phenomena, a rain/snow shadow caused by the Sierra Mountains. Precipitation is wrung out of the clouds as they are lifted over the Sierra from the west, leaving little or no moisture to fall on the eastern slopes ... desert terrain is the result.



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